Eng. Lib.

GENERAL LIBRARY,
UNIV. OF MICH.
AUG 25 191

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1860

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1910, by Munn & Co., Inc.
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXXII., No. 1860. NEW YORK, AUGUST 26, 1911. Scientific American Suppplement, $5 a year.
Scientific American and Supplement, $8 a year.

The Potter's Clay Industry of Cornwall

By Harold J. Shepstone.

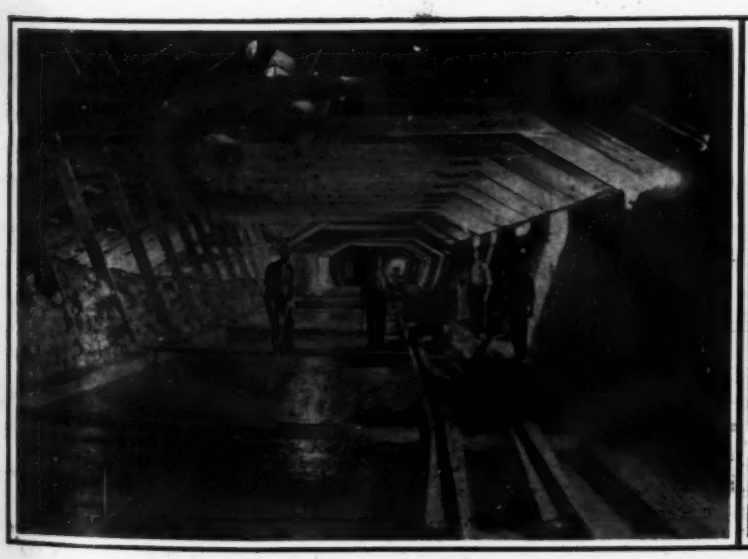
It is more than a century and a half ago since William Cookworthy rambled over the Cornish moors with his "dowsing-rod" (in the divining properties of which he was a firm believer) prosecuting his researches and experimenting upon the properties of the different natural productions of Cornwall in relation to porcelain, a subject in which he took a great interest. These inquiries and researches ultimately led to the discovery of the materials for the manufacture of genuine porcelain, a discovery of world-wide interest and importance, which has led to immense commercial results.

It is true, of course, that potter's clay had been found in various parts of Great Britain. So far back as the fourteenth century we find that quantities of this material were exported from England, principally to Holland. None of it was obtained, however, from Cornwall, the present great potter's clay producing district of the United Kingdom and for that matter in the world.

Before describing the methods now in vogue for securing the clay, a brief reference to the early history of this important industry will not be inappropriate. We find that the manufacture of porcelain from potter's clay was commenced in Plymouth, and in 1768 their discoverer took out a patent for "a kind of porcelain newly invented, composed of moorstone or growan, and growan clay." The Plymouth venture being unprofitable and progress slow, the patent rights were assigned in 1773 to Richard Champion of Bristol, who later (about 1777) disposed of them to a syndicate of Staffordshire potters. Several attempts were made to monopolize the products of the Cornish clay mines. Fortunes were spent in defeating these efforts, special acts of Parliament being necessary to secure open use of this most valuable commodity.

Cornish clay is chemically identical with the kaolin of the Chinese. It is found in a state of partly decomposed granite. The cause of the decomposition is not positively known, geologists differing in their views on the subject. Granites are rocks which have welled up in a molten state from somewhere in the earth's crust, and crystalized on cooling. Felspar, quartz, and mica are the principal minerals composing the Cornish granite, and the decomposed felspar gives us China clay. China clay is not found as such, but is mixed with quartz and mica. The "raw material" in its natural state is held together by the plasticity of its clay parts, and con-

A Fully Opened Mine in Operation.



Interior of a "Dry," Showing Tramway on One Side and Floor on Which the Clay is Spread.

Removing the Surface Material, the So-called Overburden, to Get at the Clay.

THE POTTER'S CLAY INDUSTRY OF CORNWALL.

sequently the mass is easily and readily broken up.

When a clay bed is located, trials are made to ascertain if it is of sufficient area and depth to be worth working. If so, shafts are sunk in the center and on the edge of the deposit to its full depth, and the bottoms of the shafts connected by a tunnel driven horizontally. Some of the larger mines will yield from 30,000 to 40,000 tons of the raw material per annum. The clay beds vary in depth from 60 feet to 200 feet and are covered by valueless surface earth varying in depth from 3 feet to 50 feet. This "overburden," as it is called, is removed from around the top of the "washing" central shaft for the first operations and the clearance gradually widened as needed for uncovering the clay bed.

A kind of basin is formed in the exposed clay bed around the shaft, and the sloping sides having been cut into channels, or streaks, workmen locally known as "dubbers" break up the masses of the material into lumps about the size of a large ball. Water is then streamed over the edge of the basin, from open conduits called "launders" on the surface. After it flows through the streaks, disintegration of the mass commences.

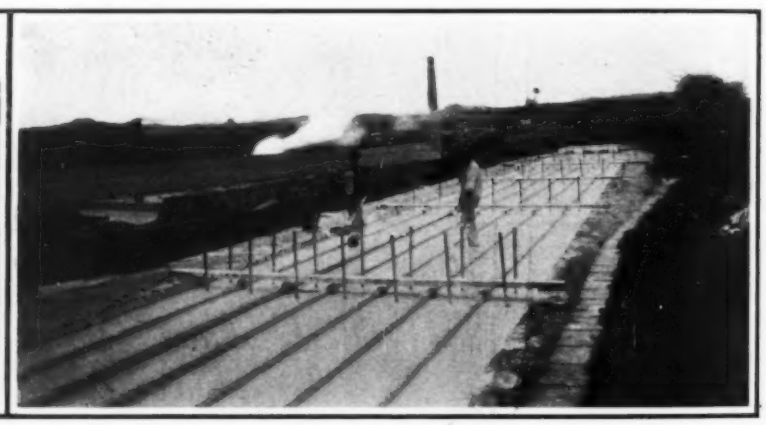
The dubber continues his pounding to assist the separation of the mass, which, in gradually diminishing particles, gravitates towards the mouth of the shaft, before reaching which the heavier parts of the quartz and sand are trapped in a wooden frame pit, or sand drag. The lighter parts of clay and mica are carried in suspension in the water to the bottom of the shafts. This is the first process. At its conclusion the refuse, five-sixths of the original mass, is "trammed" to the waste heap on the surface to make way for the next "washing." About 600 gallons of water per minute pass over the streaks, and as the clay water runs into the shaft the proportion of solid matter to water is about 3½ ounces to the gallon.

clear water passes out at a slightly lower level on the opposite side, leaving the mass in its 1 to 7 consistency behind. The clear water passes into a reservoir and is pumped back to the mine to be used over and over again. From the settling pits the thick liquid passes through hatchways and earthenware pipes into adjoining tanks for a further extraction of water. These tanks are large reservoirs about 150 feet long by 60 feet wide and 8 feet deep. A number of "settlings" go to fill up a tank. When a tank is full the clear water, which rises slowly to the drains in the sides is allowed to remain for a period of from three to six weeks. Further evaporation takes place, and when the proportions are one of water to one of clay the open air processes of drying are completed. The clay is dug out and "trammed" into the "dry," as the covered kiln which completes the separation is called.

The wet clay is spread over the pan or floor of the dry to a depth of about eight inches in the average, being deeper at the fire end. A furnace at one end furnishes heat which passes in flues, underneath the pans, through the whole length of the dry, and passes out through a chimney stack at the other end. At a certain stage in this forced drying, the clay is run through with a "cutter" which is dragged through the soft mass, first lengthwise and then across, forming the clay into cubical blocks. This assists the drying by enlarging the exposed evaporating surface, and divides the clay into lumps of a convenient size to handle when removing from the pan into the "linhay," which is a roofed-in shed running alongside the dry throughout its whole length, and serving as a store-room till the clay is loaded into railroad trucks or otherwise packed away.

The time occupied in this process varies from twelve hours at the fire end to ninety-six hours at the stack end. Experiments have shown that when the clay has been thus dried it still contains about ten per cent of

Settling Pit With Reservoir for Clear Water.



Separating the Mica From the Clay.

THE POTTER'S CLAY INDUSTRY OF CORNWALL.

It is the purpose of the second operation to separate the mica from the clay, which is done by a process of sedimentation in a surface trough, known as a mica. The clay water is pumped from the shaft on a fringe of deposit by engines. Up till recently the type of machine employed was that adopted a century and a quarter ago. Now modern gas engines are used in the more up-to-date mines. The clay water enters the mica through pipes and is streamed over its whole surface, about 200 feet by 30 feet. The mica is cut up into smaller troughs about 25 feet long by 2 feet wide. The boards framing these inner troughs are in their short lengths placed at right angles to intercept the flow of clay water at regular intervals, and are sufficiently high to cause a slight pooling of the stream, but low enough to allow the top of the stream to flow over, carrying the finer particles of the "material" with it.

By the time the stream reaches the end of the mica only the purified clay remains in the water, the mica and what little fine sand may have remained from the washing having settled against the cross boards, the heavier particles in the first line of troughs, and gradually diminishing in the passage. Leaving the sediment—which looks like thick cream—to be discharged through holes opened in the bottom of each trough by the removal of a plug, the clay in suspension, which upon entry into the mica is about 1 part solids to 25 parts water, passes through underground pipes to the settling pits, where the separation of the purified clay from the water commences.

In the settling pits the relative proportions of clay and water are at entrance 1 to 50, and at close 1 to 7. The clay sinks in the pit, which is about 30 feet in diameter, and about 6 feet deep, and the water clears itself of clay by the time it reaches the top of the pit. The clay water enters on one side of the pit and the

constitutional water, that is, the water which is chemically combined with the clay, and to the possession of which it owes its plastic properties. This water can be entirely eliminated only by heating the clay to a red heat.

Until very recently the clay was "settled" in out of door pans, and taken up in lumps as soon as sufficiently set and put into bags, which were exposed upon walls in thatch covered sheds, the sides and ends of the building being left open for air to pass through freely. A few of these drying sheds are still to be seen. They contrast markedly with the 380 feet structures now in operation at the more up-to-date mines. The old-time "sun pans" were usually square or oblong, and varied in size, but usually were about 18 inches deep. The drying was entirely by evaporation. Later, the whole of the clay was dried in the open and the supply was then very much a question of "weather permitting." In the early days of the industry it is said "one year's output of 100 tons created a glut in the clay market." Contrast this with the 600,000 tons of the present time, and we get an idea of the extent of the Cornish clay industry.

The Duration of Geological Time

In a very interesting letter addressed to *Nature*, Mr. Arthur Holmes suggests a new method for estimating the antiquity of geological strata:

"There is at the present time a great discrepancy in the numerical values given for geological time by the various methods employed. Considering the period which has elapsed since the commencement of the Cambrian, the evidence afforded by the study of radio-active minerals suggests that its length is of the order of 500 million years. Arguments derived from the study of sedimentation give, according to recent writers, a space of time for the same period not exceeding 50 million years, and the method based on the salinity of the ocean gives a similar figure. It is with regard to sedimentation that I wish here to make a few remarks.

"It is evident that at the present time the volume of post-Eozoic sediments in existence is greater than ever it has been, and also that it is slowly increasing at the expense of the igneous and pre-Cambrian rocks now exposed to denudation. Knowing the rate of this denudation and the total volume of these sediments, all of which must necessarily have had their origin in igneous and pre-Cambrian rocks, the period represented by the fossiliferous strata is given by a simple process of division.

"Situated as I am in Africa, without any geological literature, I can only give the most approximate estimates of the necessary factors with which to illustrate the method and arrive at the required length of time.

"Sollas gives the thickness of the post-Eozoic sediments as 250,000 feet, or approximately 50 miles.

"If we suppose all the sediments to be deposited at the maximum rate, they will form a regular bed along the continental shores for a distance of 35 miles seaward. Taking 100,000 miles as the average shore line of the Cambrian and subsequent periods, we arrive at the total volume of sediments—175×10^4 cubic miles. This spread over the whole globe represents a thickness of seven-eighths of a mile.

"The average rate of continental denudation is probably 1 foot in 5,000 years, or 1 mile in 26 million years. The continental area is 56 million square miles, one quarter of which is occupied by igneous and pre-Cambrian rocks, i. e., 14 million square miles. The rate of denudation of the latter is therefore 14 million cubic miles in 26 million years. The time for all the sediments to collect at that rate would be 325 million years. This figure is only an indication of the order of the time elapsed. It requires to be corrected for the following factors:

"A. Factors tending to decrease the estimate.

(1) Exposed surface of igneous and pre-Cambrian rocks may have been greater in former ages.

(2) Marine denudation of igneous and pre-Cambrian coasts.

(3) Greater density of igneous rocks than of sediments.

B. Factors tending to increase the estimate.

(1) Average land area has probably been about 0.8 that of to-day.

(2) Average continental mean height has probably been below that of to-day.

(3) Recent glaciation has laid bare many pre-Cambrian areas.

(4) Present is a volcanic period, increasing the weathering capacity of rain.

(5) Present climates are of maximum variability.

(6) Parts of land area are subject to deposition, i. e., negative denudation.

(7) Unconformities not represented by sediments elsewhere.

(8) Some sediments at great depths may have become igneous rocks.

"It is hoped that, with the increase of accurate quantitative knowledge of former conditions, and of the processes at work in denudation and deposition, the above factors may be verified and allowed for in making an estimate of the antiquity of sediments.

"The estimate here given is probably too low in the light of these corrective factors, and it is interesting to notice how much more closely it agrees with the results of the totally independent method based on radio-activity than do those deduced from the facts of sedimentation in the usual way."

Logistics*

By Major William C. Bartlett, U. S. Army

THAT which strikes the average reader of the history of the Franco-German War of 1870-71 is, not so much the multitude of combatants arrayed on either side as the marvelous rapidity with which the armed forces of Germany were assembled and launched at the foe, as though the long-roll had been sounded in every home throughout the land. Gradually he realizes that the dear old metaphor of watching the war-clouds gather must be given up, and that future war, like a cyclone, will have rushed down and past, leaving nothing but wreck and ruin behind, long before the bystander will have thought to look for its approach.

To the idea of large armies of men his mind has become accustomed. Did not Darius 332 years before the Christian era bring 600,000 combatants to the battle of Issus? Does not Polybius place the armies of Italy, when threatened by the Gauls in 326 B. C., at 768,300, and have not the often heard stories of the old soldier led him to think lightly of such a trifle as an army of a few hundred thousand? But this suddenness of action is something novel; and having his attention once called to it he finds that it is not peculiar to the German army, but is the salient feature of all the latter wars of this era!

To show this more clearly, let us compare the War of the Rebellion in this country with two of the recent European wars.

The United States Army, in October, 1861, numbered 250,000 men; on May 1st, 1865, it comprised 1,034,000, having in 3½ years increased by 784,000 men.

On the 3rd of May, 1866, the Prussian army strength was 210,000, and within six weeks this was raised to 600,000, of whom 230,000 were in the field at Sadowa on July 3rd. On the 14th of July, 1870, the armies of the States now comprised in the German Empire numbered 382,568. In two weeks 440,000 men were concentrated on the Rhine, and by August 15th, or in one month, there were 1,183,389 men under arms, of whom 650,000 were at the front. Nor was this the limit of their expansion, for in February and March, 1871, their average total strength was 1,350,587.

Such a number is in itself not easy to read, still more awkward to write, and hardly possible to grasp in its entirety, unless some standard be given by which to measure it. When Gen. McClellan marched from Washington to attack the Confederates he was censured by the Cabinet for moving by five different roads, and in reply stated that he marched the entire army (about 100,000 men) by one road, the column, with its trains, would have extended about fifty miles. Taking, then, the measure of fifty miles to each 100,000 men, which other observations have shown to be approximately correct, the German army in February and March, 1871, would, if marching with its baggage on a single road, have extended a distance of 675 miles. In other words, the leading division would just have gone into camp at Detroit, Mich., as the rear-guard was filing over the bridge at this post. What, then, is the mainspring which not only gathers this mighty force together, but also sets it in motion against the enemy? The answer is, Logistics. Having but a hazy notion of what logistics is, you, turn to some military textbook on the art of war. Should it happen to be Hamley, you will not find the word in the index, but Jomini greets you with it right at the beginning, and also gives you a definition: Logistics, or the art of moving armies. Very short and simple! But when you come to the third chapter he has arrived at the conclusion that logistics comprises the means and arrangements which work out strategy and tactics, and reaching the forty-first article of his book, you discover that he is puzzled over his own former definitions. He then explains that the term originally came from the French title, "major-general de logis," synonymous to our quartermaster, an officer whose duty it formerly was to lodge and camp the troops; but as war became more complicated the duties of these staff officers became more extended, until finally they were connected with all the operations of a campaign. "To be a good chief of staff," he says, "it became in this way necessary that a man should be acquainted with all the various branches of the art of war. If the term logistics includes all this, the two works of the Archduke Charles, the voluminous treatises of Guibert, Laroche, Aymon, Bousmard and Ternay all taken together would hardly give even an incomplete sketch of what logistics is; for it would be nothing more or less than the science of applying all possible military knowledge."

There is no doubt but Jomini is right; so that instead of going into every detail of this big subject, which includes everything connected with the preparing, supplying, moving and guarding of an army from the first call to arms to the final disbandment, we will confine ourselves to eight subdivisions, which seem to be the most important, viz.: Mobilization, Transport, Supply and Equipment, Marches, Magazines and Depots of Supply, Gathering Information, the General Staff and the Influence of Recent Inventions on Logistics. The majority of the examples and statistics will be taken from the Franco-German War of '70-'71; and the aim of this paper will be more to show the vastness and importance of a thorough system of logistics than to go into each minute subdivision of the art. Every European State but England has adopted some form of military organization based upon the fundamental rule of universal liability to military service, by which the whole available male population of a country is divided into certain classes, each of which is called out as required; but only those classes which are composed of able-bodied men of a certain age are included in the war strength of a nation.

This system was first practised by Prussia, having been forced upon her by Napoleon in 1806, when he limited the strength of her standing army to 42,000, without, however, stipulating how long the men should serve. General Scharnhorst consequently introduced a method by which recruits were kept in the ranks a certain time and then allowed to go home on furlough their places being filled by fresh men. The development of this plan, now called mobilization, enabled North Germany to collect her armies in eight days in July, 1870. Mobilization, however, does not merely bring the masses of men together; it also equips, arms and supplies them, so that when assembled they are ready to take the field. Writing on this subject, Gen. Merritt says: "The wonderful preparation of the German army down to the smallest minutiæ, the close calculations of the capacity of the means of transportation, the brilliant combinations accomplished to the smallest part of a day, were such that it was only necessary to insert the date of the first day of mobilization in the marching and time-tables for the movement of the troops to commence and the dates of their arrival at the point of concentration to be known." Some notion of the amount of work involved may be gathered from the fact that all the railways in North Germany were solely employed for eight days in carrying it out. But it would seem that the limit of rapidity in mobilization had not then been reached, for it is now stated that France can mobilize and deploy her army in fourteen days and Russia in six weeks, while the German cavalry divisions are always ready to take the field in twelve hours and the army corps nearest the Rhine can be mobilized in forty-eight hours.

The great factor in this celerity of assembly is the railway. "Facility of transportation by the agency of steam has made it possible to subsist enormous bodies of men and to move them over large distances in a very short space of time." In 1870 the Germans transported 280,000 men an average distance of 300 miles in eight days, using six double-track lines. The number of troop trains despatched each day was only twenty-four on each road, but seeing that the managers of all the English main lines assert their ability to run 180 trains every twenty-four hours on each of their roads, there seems to be a possibility of effecting such a concentration in at most two days. In the Italian War of 1859, 12,000 men and 650 horses were carried from Paris to Marseilles, a distance of about 400 miles, in twenty-four hours. General Hooker's corps, 23,000 men, with all its baggage, was transported in seven days from the Rapidan to Stephenson, Ala., a distance of 1,192 miles, over single-track roads. But there is a limit beyond which there is no time gained in moving large bodies of troops by rail. Gen. Wolseley estimates that for English double-line railways 600 cavalry and infantry, with their proportion of guns and baggage, is the maximum number to the mile of distance to be made that can be advantageously transported. For short distances, therefore, there can be no doubt but that it is better to march troops than to carry them by rail.

The following are some of the estimates given for American railroad transportation:

It takes about 150 troops trains to transport a corps and its equipment.

One passenger car seats fifty-six men; can carry seventy-five to one hundred.

One box or flat car can carry ten to twenty tons of stores.

One flat car can carry two guns, limbers and caissons if properly packed, or two army wagons loaded.

One horse-car can contain fifteen to seventeen horses.

Half an hour is the time allowed for loading a field battery or squadron of cavalry, provided proper platforms are furnished. Infantry can embark in a few minutes.

All railways used for strategical purposes should be of the same gage. Great inconvenience and delay was caused in the Turco-Russian War of 1877 by the fact of the Roumanian and Russian lines being of different gages. Another essential is that the roads should be under the full control of the military authorities. Most European armies have a special branch of the staff which attends to railroading alone. In England there is a volunteer railroad corps, in which the managers of many of the leading lines are commanding officers of the various battalions; and during the Rebellion in this country the railways, except those captured from the enemy, although under Government control, were managed by their own employees. The fatal delay of the French army during their last war in mobilization and concentration was, in great measure, due to the want of proper organization, indeed, utter disorganization, of the railway systems of the country.

Navigable rivers and the ocean furnish much surer lines of transport than do railroads, which are more vulnerable than common roads, and are, indeed, when near the frontiers of two contending States, nearly certain to be destroyed. The Comte de Paris is authority for the statement that, whenever the Federals during the war of 1861 were supplied by a river their progress was certain and their conquests decisive, while the successes they obtained by following a simple line of railway were always precarious, new dangers springing up in their rear as they advanced.

The capacity of the ordinary Ohio River steamboat is about 500 tons, or as great as two freight trains of twenty cars each, and it could carry supplies for an army of 40,000 men and 18,000 horses for almost two days. In spite of the fact that the conveyance of troops by sea has been enormously facilitated by modern inventions, Great Britain has not sufficient available shipping to send her miniature field-army of 88,000 men, 30,000 horses and 4,300 guns, wagons, etc., to any point which would take more than fourteen days to reach, that is, some 6,000 miles. This only applies to long voyages, however, for it is stated that the army which Napoleon gathered at Boulogne for the invasion of England, viz., 114,000 men, 7,000 horses and 960 guns, etc., could be shipped across the channel in seventy-eight steamers of 3,000 tons each. The time taken to embark is comparatively short; two French divisions in the War of 1859 were placed aboard ship in ten hours. On March 17th, 1862, Gen. McClellan's army began its embarkation at Washington, Perryville and Alexandria, and by April 5th there had been transported to Fortress Monroe, a distance of 188 miles, 121,500 men, 14,592 animals, 1,150 wagons, 44 batteries, 74 ambulances, besides pontoon bridges, telegraph material and the other equipage required for an army of that size.

It is where rail and water communications are wanting that the most serious question of transportation is encountered, and one which in spite of their care and provision greatly troubled the German armies, that of wagon carriage. Gen. Hamley tells us that the supply trains of the German army in an enemy's country consist of 560 wagons for each corps; 400 of these are to draw subsistence stores from the magazines and 160 are immediately attached to the corps. There were altogether in France fourteen organized German corps, besides the Grand Corps and some unassigned divisions. Taking the whole as sixteen corps, the total number of wagons constantly employed in the transport of provisions and forage alone was 8,960, which would in one column cover a distance of ninety miles. Even this large number did not prove sufficient, and notwithstanding the activity of their light cavalry in seizing the country wagons of the French, the complaint of want of vehicles to carry their supplies from the railroads to their various points of operations, usually but short distances away, is constantly met with in their official reports. Taking the amount of wagon transportation which Gen. Sherman's army had on the march from Atlanta to Savannah as a basis, it will be found that had the German armies which first entered France been cut off from their base and been compelled to depend upon foraging for subsistence it would have taken 11,525, or 136 miles of wagons, to have carried five days' rations and grain for them and to have left enough empty wagons to bring in the captured provisions.

(To be continued.)

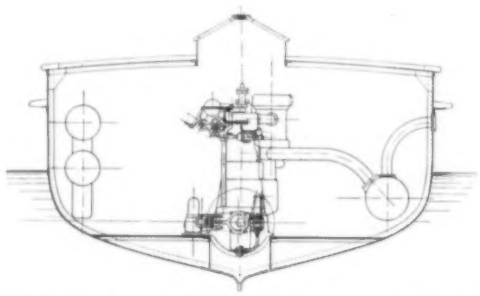
* *Journal of the Military Service Institution.*

The Marine Diesel Engine

A Reversible Engine That Can Be Used Like a Steam Engine

THE gasoline and oil engines hitherto employed for marine use have been almost without exception of the well-known stationary non-reversible type. A reversible engine which can be used like a steam engine to drive the propeller, to change the speed or to reverse in an instant, had not heretofore been built, but is now before us in the new Sulzer-Diesel marine engine, recently built in Switzerland. The advantages of oil engines for marine use are well understood, and include, among other things, such obvious features as the small bulk and weight, both of the fuel and of the machinery itself. The advantages of the oil engine are particularly accentuated in the case of the Sulzer-Diesel motor, inasmuch as it can be run with heavy oils, such as petroleum residues and other products which cannot be used in ordinary gasoline engines, owing to the difficulty of producing ignition. In the new motor the oil is not carbureted as in the common type of automobile motor, but is introduced into the cylinder by compressed air in the form of a spray. As is well known, the Diesel engine uses no separate igniter, the gas within the cylinder being spontaneously ignited by the heat of compression. This arrangement makes it possible to very accurately regulate the amount of oil fed in at each stroke when running under a given load. At the same time, a governor automatically controls the feed for different loads, so that when the engine is running, this feature requires no further attention.

As the liquid fuel employed has a high flash point, there is no danger of explosion or fire: on the other hand, there is no fear of any poisonous gases being spread, as is apt to occur in the case of producer-gas plants, where they have not infrequently been the cause of dangerous and even fatal cases of asphyxia. This feature is of particular importance for marine work, in view of the limited space and difficulty of ventilation on board a ship. As the combustion in the Sulzer-Diesel engine is almost perfect, the motor keeps very clean and is not at all apt to become clogged with dirt, even after a long run. There are cases on record in which such a motor has run for several years, often working for weeks at a time without stopping. Cleaning is necessary only at long intervals. These points also are of particular importance for marine motors, as is also the fact that the engine is always ready to start, requiring no ring up or other preparation, as there is no boiler or gas producer to start up. The engine can be started at short notice in two or three minutes, a reserve of compressed air being held in readiness for this purpose in steel cylinders charged by the motor itself in a previous run. The description given so far applies to the regular stationary type of the Sulzer-Diesel engine. The important feature about the new marine model is its reversibility. Almost without exception the gas or gasoline engines built for marine work heretofore have been of the usual non-reversible type, similar to the automobile motor. With such engines it is necessary either to use a special reversing gear, or else to provide a propeller with reversible blades. Even where reversible oil engines were tried, they had to be uncoupled from the propeller shaft, then reversed, and finally re-connected to the shaft, since it was impossible to reverse them while driving the screw. A high-power engine cannot be built in this way, for when

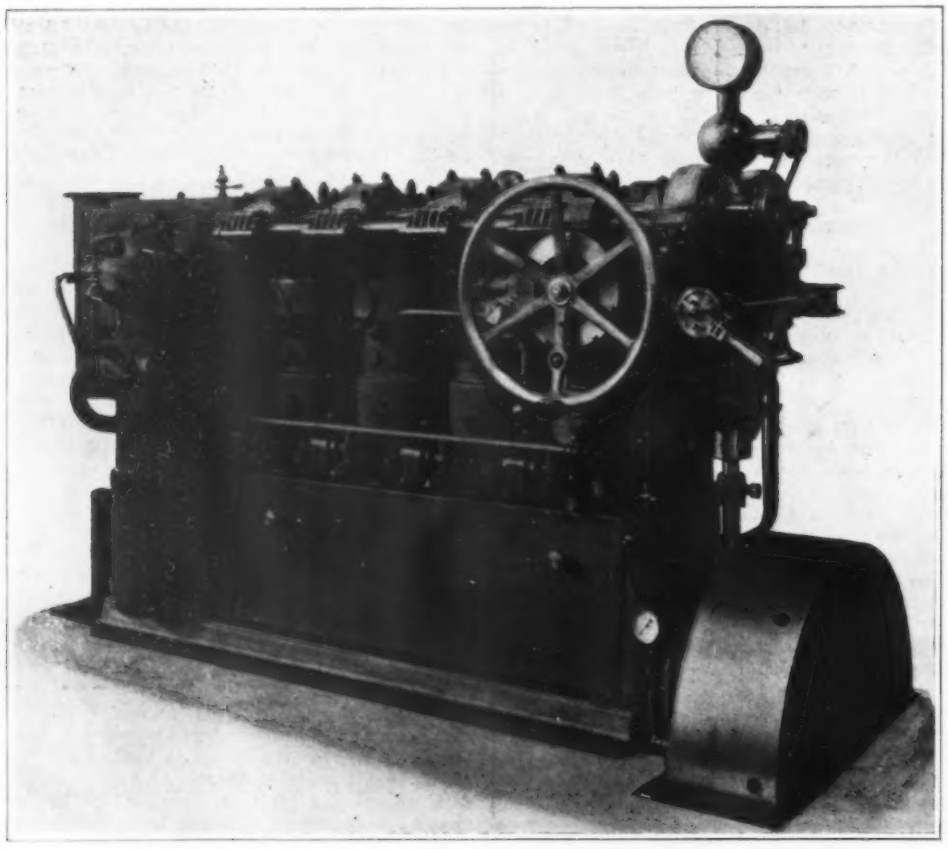


The Diesel Marine Motor in Position. Horse-power 100. Total Weight 5 tons.

uncoupled from the propeller it is very apt to race. Besides, the operation of uncoupling and recoupling takes some time, and during the interval the operator has no control over the propeller. On the other hand, it appears that neither friction clutches nor reversible propeller blades can very well be used with high-power engines.

The accompanying engraving shows the new reversible Sulzer-Diesel marine engine. It differs from the previous forms of Diesel engines by being designed for two strokes instead of four. The new motor carries four cylinders, so that it starts up easily in any position. A much lighter fly wheel is used than hitherto. An air pump is mounted together with the engine, for use with the oil feed, and a second air pump is provided for the purpose of cooling the cylinders. The starting and reversing is readily carried out by hand.

A small hand wheel controls the oil feed and thus regulates speed and power. A set of small compressed air cylinders and an oil tank complete the outfit, which altogether does not weigh more than the steam engine alone of a torpedo boat of the same power. At the present time the total weight, exclusive of the propeller and shaft, does not exceed 60 to 100 pounds to the horse-power. The engine can be built in sizes up to a thousand horse-power and more.



THE REVERSIBLE DIESEL MOTOR—SPECIAL DESIGN FOR MARINE USE.

Production of Pig Iron by Electricity*

From Consul Stuart J. Fuller, Gothenburg, Sweden.

The first report of the experiments in the reduction of iron ore in electric blast furnaces at Trollhatten, in the Gothenburg consular district, has now been made public by the Jarnkontoret, or Iron Institute of Sweden, the co-operative association of Swedish iron manufacturers which, with government support, provided the money necessary to build a plant large enough to approximate ordinary commercial conditions in manufacture on a large scale.

The total cost of the plant was 320,470 crowns ($85,886), which was $26,800 more than the original estimates. On the basis of the selling price for the product, which was established by the committee in charge as a basis for computing the practicability of the results, the experimental business has, however, been self supporting, even for the short period that it has been in operation.

Special attention has been given to the constructive details of the furnace, the consumption of electrodes, and best form of these to use, the consumption of electrical energy per ton of iron produced, the consumption of coal for the same, and the important problem of gas circulation and possible utilization to best advantage. In charge of these experiments has been a chief engineer, with operating engineers under him in charge of actual operation, collection of data, chemical laboratory, and drawings and calculations—in all, 28 men.

EQUIPMENT OF FURNACE—CONSUMPTION OF ELECTRODES.

The furnace is stated to have been built with four electrodes, each formed by four electrode carbons placed together in the form of a square. The dimensions of the electrodes are 2,000 by 600 by 600 millimeters (78.74 by 23.622 by 23.622 inches). Electrodes from Hoganas, Sweden, and so-called "plania" electrodes from Silesia were experimented with. Those of Swedish make were found to be equally durable but somewhat more uneven. The repairs necessary during the five months of operation are said to have been very light, so far as the smelting room is concerned, 18 hours representing the total. The circulation of the gases and their utilization will require further experiments, which are to be conducted in the present plant. Further investigation as to the best shape and dimensions for the furnace are also on the programme.

The consumption of electrodes per ton of iron produced is stated to have averaged 10.28 kilos (22.6634 pounds) gross and 5.27 kilos (11.6183 pounds) net for the whole period of operation, but, owing to improvements now developed, it is thought possible to bring down the gross consumption of electrodes to a figure approximating the net. It is also thought that greater economy would result from the use of three-phase current and six electrodes.

Up to date only unburnt limestone has been utilized, but it is thought that the use of calcined limestone will prove more economical.

It is stated that the results obtained from this five months of experimental operation warrant the opinion that the question of the economically successful reduction of iron ore in the electric furnace by the use of cheap electric energy has been solved and that the perfection of methods for handling the gases to secure a more effective circulation, if not their utilization, will greatly better the results already obtained.

CONSUMPTION OF COAL—CHEAP POWER.

The average consumption of coal for the whole period of operations has come to 922 pounds to the ton of pig iron, as against a preliminary estimate of 741 pounds. However, an average made to cover a considerable proportion of the period of operation showed a consumption of only 816 pounds, and it is hoped to better this result. The statement is made that in the introduction of new metallurgical processes the full utilization of the fuel is never reached without considerable experimentation.

It is hoped to reach the preliminary estimate of three tons of pig iron per horse-power per year in production, although the results so far have been only 2.7 tons.

Feeling that the government subvention in the shape of power furnished at a merely nominal rate is now no longer warranted, in view of the success

* From Daily Consular and Trade Reports.

of the experiments, the water-power commission has proposed to raise the price of the electric current furnished to $13.40 per kilowatt year, but as the Iron Institute claims that it can not economically keep its plant going at a rate exceeding $10.72 per annum the question of the adjustment of the rate is under consideration.

Trials have proved that the product is as well adapted to the manufacture of steel as is the ordinary Swedish pig iron. The steel made therefrom has been tried for various purposes and found to be satisfactory.

Flaws and "Diseases" of Metals

Their Metallographic Diagnosis

By the Paris Correspondent of the Scientific American

It is well known that the properties of metal are changed by forging, drawing, and other like treatment, whereby its hardness is increased, and it may be said that here the metal, in fact, is in another physical state. Just what effect takes place under these conditions, however, appears to be somewhat obscure, and the recent researches undertaken in this field by M. F. Robin, a prominent metallurgist of Paris, are most timely. This work has been indorsed by leading authorities such as M. Leon Guillet, as being a valuable contribution to the state of our knowledge, both from a theoretical and a practical standpoint.

The metals which have been given a treatment by drawing, cold rolling, etc., are of current use in the industries, and they are often preferred for the reason that the perfected machine processes give them in more exactly calibrated sizes, such as drawn steel, bronzes and brass used for lathe work, and also tubes of such metals. Researches upon the effect of mechanical treatment of metals are therefore extremely important. In general, such treatment (drawing, cold rolling, etc.) increases the toughness of the metal, and it is evident that for smaller diameters of metal, the effect is greater than for large diameters. The chemical properties are also modified, and it is shown that a mechanically treated metal alters more easily by chemical effects in the case of the untreated material. A very interesting point bears upon the contagious diseases of metals. This was first noticed in relation to tin, and consists of a change from white tin to a gray and powdery state of the metal. What is singular is that if we sow powdery tin upon the healthy or white metal the change takes place more rapidly. This was the first case where a contagious disease of a metal was noticed, but there is another which has a much greater bearing on practical work. Take a drawn or cold-rolled metal which is thereby hardened. If we apply upon it the same metal but in the softer or annealed state, the hard metal becomes softened by contagion, and this even in the cold. When heated, the effect is stronger.

According to this, all the mechanically treated metals such as drawn wires or rods are in an unstable condition, and as soon as this is disturbed by a softer metal of the same kind, the metal tends to reach a stable form. As a matter of fact, strains are set up within the metal which may even cause it to break. For instance, with stamped or spun metal such as brass lamps, part of the metal may be hardened by the process and the rest left soft, so that there is a contagion between the parts, and the metal finally breaks by internal strains. It is known that cold rolled or drawn brass is much more affected than hot-treated metal, by handling and by temperature changes. Sometimes brass bars left in the storeroom are found to crack along their whole length; due no doubt to the effect of imperfectly worked parts upon the other portions of the metal. We thus have what may be called a contagious disease of mechanically worked metals, and from a practical standpoint this is of great interest. This point, as well as many others relating to hitherto obscure properties of treated metals, are brought out in M. Robin's experiments.

The present researches bear upon the modifications which a metal undergoes when machine treated. Forging, rolling or drawing modifies the structure of metals, changing the direction of the crystalline elements and breaking the crystals. The changes of direction, and still more the breaking up of the crystals thus caused, is found to increase the resistance and the hardness of metals. The first experiments were made in order to find the hardness of steel and other metals when the operation was carried out at different heats. Cylinders of metal whose height equals the diameter are forged under a drop-hammer by determined quantities. For the different heats up to low redness, water or mercury baths were used, and the temperature is measured by a thermo-electric pyrometer. At higher heats, the samples are heated in a small firebrick furnace. Liquid air baths are used for very low temperatures. M. Robin thus obtains an extensive series of data which are of great interest.

The hardness obtained by the mechanical treatment of metals, increases with the force which is applied, but after a certain point the hardness due to this cause no longer increases, and may even fall off again slightly. Each metal has in fact a limiting value for the hardness which can be given to it by forging, drawing or rolling. This depends, however, upon the method of treatment to a certain extent.

As to the variation of hardness with the working heat, Le Chatelier remarked that the pure metals generally doubled their breaking strain by cold rolling, etc., of annealed metal. This is found to be practically true for steel by M. Robin, but for extra-soft iron it may be 2.3 times, and for copper 2.5 times. The study of copper at different heats is important for wire drawing especially. It is best drawn at 0 deg. C. (32 deg. F.), as the hardness is maximum here, falling off on either side in liquid air or at heats of 200 to 600 deg. C. (392 to 1,112 F.). Brass gives about the same results. For brass having below 35 per cent zinc the cold process is used, but the metal becomes brittle and needs to be annealed to soften it. However, with 35 to 45 per cent zinc it can be worked when hot so as to avoid annealing.

As regards carbon steel, various steels show different behavior, having in general about 100 per cent hardening by treatment. Manganese, silica, etc., increase this considerably. The point of maximum hardness is about 300 deg. C. (572 F.). As to special steels, nickel increases the hardness. For chrome-nickel steels a remarkable rise is seen above 700 deg. C. (1,292 F.), and the metal becomes as hard as tempered steel.

Mechanical treatment of metals appears to be accompanied by a slight increase in density, and the metal is here in a state which is quite different from the normal. Microscopic examination leads us to believe with Beilby, that the metal is in a pulvurent state which is unlike the ordinary crystalline condition. This pulvurent state can be likened to the liquid state, as we notice with bismuth; this metal is denser in the liquid than in the solid state, and experiment shows that worked bismuth is denser than the ordinary metal. For other metals which are less dense liquid than when solid, the density is lessened by mechanical treatment, showing that the pulvurent state lies between the solid and the liquid state. Again, mechanical treatment lessens the malleability of metals in general, but on the contrary increases that of bismuth which becomes ductile and flexible when forced through an opening by high pressure.

The structure of the surface layer of a mechanically treated metal appears to be due rather to surface tension than to crystallization forces. M. Robin examines the specimens of metal under the microscope and confirms this opinion. Cracks like those which occur in enamel or in membranes are observed. In Fig. 1 are seen the fissures produced by forging malleable brass at 300 deg. C. (572 deg. F.). The fissures given by forging steel (martensite) often cross each other at

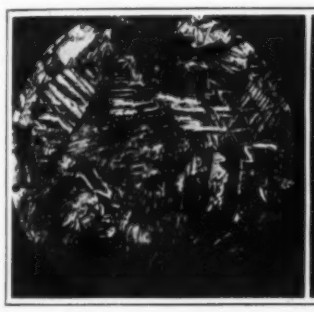


Fig. 1.—Fissures produced by forging malleable brass.

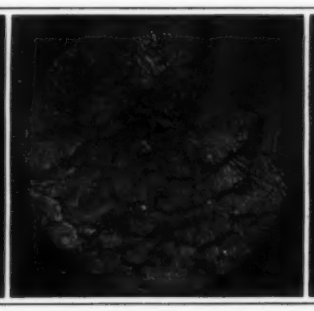


Fig. 2.—Fissures in martensite after forging.

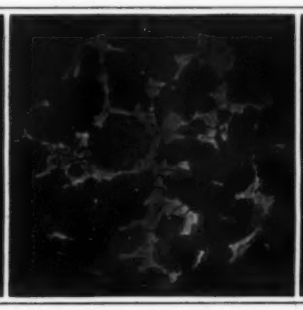


Fig. 3.—Bronze cracked by forging.

Fig. 4.—Steel containing 13% Mn. and 1% C.

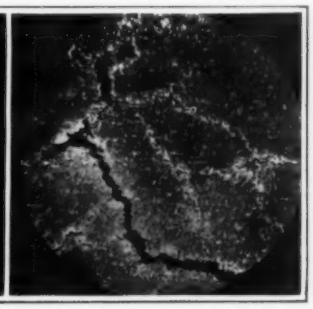


Fig. 5.—The same, forged at —185 deg. C. in liquid air.

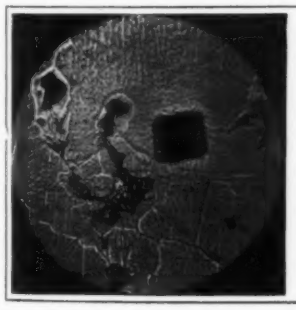


Fig 6.—Crystal embedded in phosphoritic ferrite.

Fig. 7.—"Neumann's Lines" in a specimen of steel.

Fig. 8.—"Neumann's Lines" in a piece forged at —185 deg. C.

Fig. 9.—"Neumann's Lines" in steel forged at 200 deg. C.

right angles (Fig. 2) or follow the joints of the metal grains. Fig. 3 shows the appearance of bronzes cracked by forging. Steel having 13 per cent manganese and 1 per cent carbon is found to increase in hardness by forging in liquid air, owing to the production of martensite (Figs. 4 and 5). However, a fine grain is not an essential condition for hardening, and microscopic examination cannot in general give us direct conclusions as to hardness or resistance of metals; one exception is for pure ferrite (Fig. 6), and it has then a better and a larger crystalization.

In some cases what are known as "Neumann's lines" are formed, and these are well displayed in steels having large crystalline parts such as phosphorus ferrite (Fig. 7). The development of these lines seems to follow the brittleness of a metal but not the hardness due to treatment. Lines so developed, are also seen in Figs. 8 and 9.

Practical Aspects of Printing Telegraphy—V*

An Inventor on the Difficulties to be Encountered and the Way to Overcome Them

By Donald Murray, M.A.

Continued from Supplement No. 1859 page 119

ALPHABETICAL TROUBLES.

Nor only is there great difficulty in getting a printing telegraph to work perfectly and to save time, labor, and telegraph line; but also, if it is to go into extensive use, it must have sufficient elasticity to fit in with the requirements of various telegraph administrations. Reference has already been made to the varying conditions to be found in different parts of Europe. One of the most serious difficulties arises out of lack of uniformity in language. The general effects of the limits imposed by diversities of language have already been referred to, but there is one special aspect of this matter that needs further attention. Out of the varying languages spring varying alphabets, and a printing telegraph suitable for use in English-speaking countries is by no means suitable forthwith for countries using another language. Out of these varying alphabets spring up several mechanical troubles. One of the chief mechanical problems in a printing telegraph is the same as in a typewriter, namely, to bring any one of a given number of type to one printing point and to return it to its position of rest in the shortest possible time. The size of the type which it is convenient to read and which prints clearly under typewriter conditions has an important bearing on the question. There are fairly definite limitations in regard to the size of the type. There are also limitations to the number of type if operation is not to be very slow. A typewriter, for instance, with 10,000 different characters would have typebars 15 feet long, or if it was a type-wheel machine the type-wheel would be over 10 feet in diameter. Typewriters seldom have more than 90 characters. That is about the limit of what is practicable. Serious mechanical difficulties arise with the introduction of any greater number of characters. With printing telegraphs there are still further limitations arising out of the codes of signals. These impose a practical limit of about 50 to 60 characters. For instance, with the 5-unit alphabet used in the Baudot and the Murray systems, there are 32 possible signal groups (permutations of five things taken, 1, 2, 3, 4, and 5 at a time). By using a shift key this number can be doubled, but as the space signal and two or three operation signals have to be provided for there are practically about 54 characters that it is possible to transmit with the 5-unit alphabet. A second shift key may be used, giving about 120 different characters, but two shifts entail too much loss of time in operation, and it is very desirable to adhere to one shift only. As we are confined to about 54 characters, and as we have to provide 10 numerals and about 15 punctuation marks and other figures, it is not practicable to provide both capitals and small letters. It is usual in printing telegraphs to employ capital letters only, but the German Telegraph Administration prefers small letters only, scientific investigation having shown that small letters are more distinct and easily read than capital letters. There is no difficulty in providing for that difference in practice; but when we are limited to 54 characters, and when each country requires some special character—usually several accented letters—the difficulty in the case of a printing telegraph that aspires to be used internationally becomes serious.

Looking through the alphabets of the leading languages of Europe (excluding Russia, which has a special alphabet of its own) we find the following characters:—

COMMON TO ALL.

abcdefghijklmnopqrstuvwxyz 1234567890

. , ? — ( ) ' ' " " / %

SPECIAL CHARACTERS.

Germany.—The three modified vowels *ä, ö, ü*, although in general use in all printed matter in Germany, are not employed in the German telegraph service, *ae, oe and ue* being used instead. Germany follows closely the International Telegraph Convention list of characters, and therefore requires—

: & ! ; =

Austria.—Special requirements in Austria are—

$\check{s}\ \check{z}\ \check{r}\ \check{n}\ \check{c}$ ‡ !

Hungary.—In the Hungarian language there are a variety of accented letters, amongst others the following:—

$\ddot{o}\ \acute{o}\ \ddot{o}\ \acute{u}\ \acute{e}\ \acute{a}$

Italy.—The grave accent is used with all the vowels in Italy, but in the telegraph service only *à è ò ù* are employed, and these only in Morse. For the Hughes the accents are dropped, and for the Baudot the Baudot characters are employed. *è* is practically the only accented letter actually employed. It is substituted for *ø* in Italy and in the Italian telegraph service to France.

France.—The accented letters *é è à* are common in French words, but only *é* is used in telegrams. In the Baudot systems, in addition to the letters and numerals and the International Convention punctuation marks, there are a number of special characters as follows:—

$\acute{e}$ £ ¤ ¤ No. ½ !

Norway.—The telegraphic alphabet employed in Norway calls for—

: *æ ö é* " = !

Sweden.—The telegraphic alphabet used in Sweden provides for—

a ä ö : ; *é* !

Spain.—The International Telegraph Convention alphabet is closely followed in Spain. The Spanish accented vowels are the reverse of the Italian and carry the acute accent—

á é í ó ú ñ

but they are not used in telegrams, except *é*, and it is only on very rare occasions that it is necessary to explain at the bottom of a message that a vowel in a certain word is accented. *n* is usually employed for *ñ*.

INTERNATIONAL MURRAY KEYBOARD

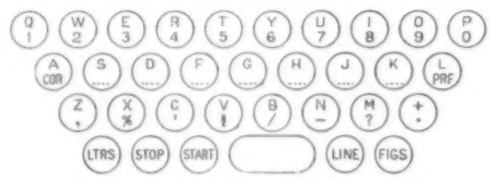


Fig. 1.

RUSSIAN MURRAY KEYBOARD

Fig. 2.

England.—The confusion between fractions and shillings through the use of the fraction stroke / has recently led to the employment in the British telegraph service of the special character | as the shilling stroke, the sloping / being kept for fractions. A special character has also been introduced to separate whole numbers from fractions thus, 2 3/8. Otherwise there are no special characters required in English telegrams, and there are no accents in the English alphabet.

International Convention.—The alphabet provided by the International Telegraph Convention, in addition to the 26 letters of the alphabet and 10 numerals, employs the following punctuation and other marks:—

. , ; : ? ! ' ' " " + — / = ( ) & ×

Several of these characters are quite useless for telegraphic purposes, as they are never required. No one ever wants to telegraph a semi-colon, for instance. The administrations, however, adhere to the convention more or less and the characters have to be provided.

Cable Companies.—Most of the cable companies provide Morse signals for—

ä á or a é ñ ö ü ! ; :

but they are seldom required.

Esperanto.—The Esperanto alphabet only calls for notice as an amusing curiosity. It employs the circumflex accented letters—

$\hat{c}\ \hat{g}\ \hat{h}\ \hat{j}\ \hat{s}$ and $\breve{u}$.

One of the chief advantages of an international language would be for international telegrams, but it is not quite clear how these accented letters are to be telegraphed.

Russia.—The Russian language is provided with a commodious alphabet of its own with 36 characters. It is impossible to send telegrams in this alphabet outside of Russia.

Japan.—The Japanese language is represented by an alphabet of 48 letters, 10 numerals, 7 punctuation and other marks, in all 65 characters. As in the case of the Russian alphabet, it is impossible to send telegrams in the Japanese alphabet outside of Japan.

Summing up, it will be seen that any printing telegraph system aspiring to suit merely the leading European languages, excluding Russia, would have to provide—

26 ordinary letters of the alphabet.
10 numerals.
18 punctuation marks.
16 accented letters and other special characters (probably more than 16).

—

70 characters in all.

In the Murray systems the difficulty was overcome by providing an international keyboard and reserving seven characters for national use, as in Fig. 1.

The secondary positions on key buttons S D F G H J K are reserved for national characters to be used in telegrams not passing out of one country. The idea is that a telegram using only the international characters shown in the diagram can be transmitted and retransmitted automatically on the Murray systems on Murray circuits on any international lines to any point required—for instance, from Dublin through London and Berlin on to St. Petersburg.

This keyboard arrangement worked satisfactorily until the Murray system was installed in Sweden. It was then found that *W x* and *y* are seldom used in Sweden, and *a a* and *ö* are frequently used. Owing to the loss of time arising from putting them in the secondary positions for national characters, it was decided to put these accented letters in the place of *w x* and *y* in the primary positions, *w x* and *y* going into secondary positions. This has made a break—the only break, so far, in the internationality of the Murray systems. In Norway they adhere to the international arrangement of the Murray keyboard.

In Russia the alphabet difficulty appeared at first sight to be insurmountable, because a printing telegraph in Russia must print both Roman and Russian letters. As there are 26 Roman letters and 36 Russian and 10 numerals, and about 15 other necessary figures and punctuation marks, we have about 87 characters in all to be provided. The Hughes and Baudot systems, both of which are extensively used in Russia, overcame the difficulty by providing two distinct type-wheels, one with Roman type and the other with Russian type. When in a Russian message a word in Roman letters has to be transmitted, the sending operator has a special call to attract the attention of the receiving operator, who then shifts the type-wheels on their spindle so as to bring the Roman letter-wheel into printing position, and *vice versa*. This rather clumsy device serves its purpose well, but it is not applicable in the case of a typebar typewriter like that used in the Murray automatic system. It is also not automatic. In the case of the Murray automatic system the difficulty was overcome as follows:—

Out of 36 letters in the Russian alphabet only about

* Paper read before the Institute of Electrical Engineers.

33 are really necessary, and one of these bI, can be printed by using two other letters. This leaves 32 characters to be provided; 13 of these are the same as the Roman alphabet though representing different sounds. H, for instance, in Russian represents the Roman N; P is R and C is S. This reduced the number of characters required to print both Russian and Roman to 64. This was practicable, and it was provided by two shift keys. One key shifts from letters to figures and the other key shifts from Russian to Roman letters. The selecting mechanism is necessarily very intricate to meet such requirements, but once it is made it works well and easily, and it is automatic—that is to say, the printing of Russian or Roman letters and figures at the distant station is done entirely by the sending operator.

The Russian Murray keyboard is shown in Fig. 2.

One way out of these difficulties would be to use the 6-unit alphabet instead of the 5-unit alphabet. This would provide 64 signals, and 64 keys and no shift keys. It would meet the requirements of nearly all languages, but it has the serious drawbacks that it would increase the complexity of the apparatus in the ratio of 5 to 6, and double the size of the keyboard and the number of keys; and worst of all, it would increase the number of signals on the line from a trifle over five to six, an increase of nearly 20 per cent. This would be a distinct handicap in the case of long or difficult lines, but it would still be shorter than the Morse alphabet in the ratio of 6 to 8, in the case of the Murray automatic system. In the case of the Murray and the Baudot multiplex systems correcting and retardation segments would bring up the length of the signals nearly to the level of the Morse. It would also necessitate the abandonment of the use of a letter-shift printing mechanism corresponding to the shift-key typewriters. This would practically double the complexity of the printing mechanism in the case of the multiplex. The full non-shift keyboard with a separate key for each character is undoubtedly a little quicker than the shift-key keyboard; but the gain is only about 5 per cent, and most printing telegraphs have adopted the shift-key arrangement in preference to the extra complexity of mechanism and reduced line efficiency of the "one key one character" arrangement with its longer code of signals. The same problem confronts the typewriter manufacturers. The full keyboard non-shift key typewriters are undoubtedly somewhat more rapid in operation than the shift-key machines, but the number of shift-key typewriters, especially those of the Remington pattern, greatly exceeds the number of the full keyboard typewriters.

In the case of Japan, the alphabet difficulties are more serious even than in Russia, and the 6-unit, or some correspondently lengthened code of signals, will be a necessity. In Japan, Roman letters are not in use, and there is a special Japanese alphabet of 48 letters, 10 Arabic numerals, and 7 punctuation marks and accents, in all 65 characters as a minimum. Also, instead of reading horizontally from left to right, the Japanese read the lines vertically from top to bottom of the page and pass from line to line from right to left. It is exactly like reading a European book turned round to the right till the lines are vertical. A still more formidable difficulty is that the Japanese alphabet is used mixed up with Chinese ideographs. For this reason, up to the present, it has not been possible even to use typewriters in Japan. Some books are printed in Japan with the Japanese alphabet only, but it makes the books very voluminous. The Chinese ideographs are really a system of shorthand, one character representing one word. This greatly reduces the bulk of a book. With the exceptions of the ten ideographs, which we call Arabic numerals, it is impossible to telegraph ideographs, because we cannot spell ideographs, and spelling is the foundation of telegraphy. For telegraphic purposes in Japan it was therefore necessary to use the Japanese alphabet only, and the existence of a Japanese alphabet was found to be a very great assistance in the rapid spread of telegraphy in Japan. In addition to the 48 Japanese letters there are also 25 umlaut, or accented characters. Fortunately, as the accents are above the letters and as the letters are written in vertical columns, the accent can be printed as a separate character before and therefore above the letter. The difficulties of adapting a printing telegraph to such an alphabet are very great, and up to the present the only printing telegraphs in use in Japan are a few stock-tickers, including the Siemens and Halske Ferndrucker. The problem is very difficult but not insoluble. Instead of the 5-unit alphabet, the 6-unit alphabet, or some other corresponding lengthened alphabet or code of signals will be required. The 6-unit alphabet and a shift-key will give the required range of characters. Fortunately also the printing in vertical lines and reading the succession of lines from right to left can be provided for by inserting the message form in the typewriter in the usual way, but arranging the type to print horizontally instead of vertically, for instance, thus:—

NOW IS THE TIME
FOR ALL GOOD MEN.
1741
9513
9156

Also it is obvious, when once we think about it, that the Arabic numerals can be added horizontally just as easily as vertically. We read figures horizontally and add them vertically. The Japanese read figures vertically and add them horizontally. For instance, they write the year 1910 thus:—

1
9
1
0

In the case of China there are at least several thousand ideographic characters required for ordinary intercourse and there is no alphabet. Telegraphy of any kind, to say nothing of printing telegraphy, would be impossible under such conditions, but by numbering the ideographs and by telegraphing the numbers, the difficulty is converted into one of coding and decoding at the sending and receiving stations. So far as telegraphy is concerned, under such circumstances only the ten numerals are needed, and an extremely simple printing telegraph with only ten numerals and one or two other characters, and using the four-unit alphabet with 16 permutations, will meet all requirements. Printing telegraph apparatus to meet these requirements will be cheap, simple, and very rapid and reliable.

Of course, the alphabet difficulty only arises in the case of a printing telegraph working on an international circuit connecting two countries speaking different languages. It is chiefly in Europe, with its great variety of important languages, that the trouble exists. A printing telegraph in Europe to be really international must meet the requirements of all the leading European languages. When an ocean intervenes, printing telegraph communication is impossible at present, and the problem of conformity to two different alphabets does not arise. By a printing telegraph to be used internationally is meant a printing telegraph like the Murray automatic or multiplex that can retransmit messages automatically from a received perforated tape. Obviously, for such retransmission to be possible all over Europe, an international keyboard must be employed applicable to all the nations of Europe. That is what the Murray systems have attempted to provide, as shown in Fig. 1.

In the case of Great Britain, there are no accented letters, but there is a very curious alphabetical difficulty arising out of the similarity in the methods of writing shillings and pence and fractions. It is an insignificant little trifle, but it has caused much trouble to the British Telegraph Administration and serious loss to merchants. For instance, 7/8 is 7s. 8d. or the fraction 7⅞. The difficulty is to discover a method of avoiding the confusion. It does not occur in the case of countries not using British coinage, and international circuits between Great Britain and the Continent of Europe cannot conform to British requirements, as they are bound by the International Telegraph Convention, which provides for the use of an oblique stroke as the fraction sign and not as the shilling stroke. The Hughes, on which practically all British-Continental traffic is carried, represents fractions in this way, namely, 7/8. As an illustration of the confusion which exists, 3 7/8 may be read as 37s. 8d. or as 3⅞. Also 37/1/2 may be 37s. ½d, or £37 1s. 2d. To get over the difficulty, in the case of the Morse key and sounder a new Morse signal was introduced to indicate a break between the whole number and the fraction. This signal used to be two *M*'s —— —— It is now ———— This is liable to be confused with ———— which represents the cipher 0. Hence the fraction 3 7/8 is liable to become 307/8. Again, the new signal for the Morse oblique stroke is confusing. It used to be three *S*'s ··· ··· ··· Now it is ———— and is liable to be sent – ———— which is *ex*, and the fraction becomes 307 *ex* 8.

The following is an actual case of error in a message from abroad. The group of figures was as follows: 2½, 3¼, 4¾, 56½. It was stated to be one group, and it was received thus: 25/1631/443/8561/2.

An actual case of loss arising from this confusing occurred in the case of the following message: "Buy at 1/2¼," the meaning being "Buy at one shilling and twopence one farthing." It was telegraphed, "Buy at 1/2 1/4." The addressee read it as meaning "Buy at 1s. 2d. to 1s. 4d.," and acted accordingly.

A neat way out of the difficulty in the case of the commoner fractions is the use of what is known as superior figures:—

½ ⅔ ¾ ⅞ ⁹/₁₀

These are printed as single characters, and are followed by an ordinary numeral or numerals for the denominator. Thus ⅞ is very obviously a fraction and is distinct from 3/8, which is shillings and pence. It is useless, however, for Continental traffic.

Another suggestion was to use the oblique stroke for fractions, thus, 3/8, in accordance with the Continental practice, and to have a vertical stroke for shillings and pence, thus 3|8. This is a good plan, and it has been adopted by the British post office with the addition of a rather absurd fraction tie, thus ⁀ 3s. 8d. is therefore now printed 3|8 and 2s. 2¾d. is printed 2|2⁀3/4. This is certainly not clear to the average man, and it cannot be transmitted at all outside of Great Britain. The single quotation mark used in Norway for the same purpose is better. Also the verical shilling stroke is liable to be shortened by wear or bad printing till it is liable to be confused with the figure 1. It is rather difficult to see why the post office should not insist on the use of the symbols £. s. d., which are universally understood. The only difficulty in the way seems to be the alteration in the count of the number of words. 3/8 counts as one words; 3s. 8d. counts as four words. This fraction difficulty exists even with the Morse key, but printing telegraphs accentuate it.

Printing telegraphs also using capital letters only, the S and D do not look so clear when printed in capitals, thus 3S. 8D.

CODE AND CIPHER MESSAGES.

A serious trouble in telegraphy is the handling of code, and cipher messages. Code messages are usually understood to be those containing words apparently meaningless and having no apparent relation to one another, and cipher messages are usually understood to be messages composed of numerals with a secret meaning. In America the practice of contracting well-known words in transmission has come to be known as "coding." The word "code," however, is used here in its well-known international sense. Code messages are the usual form of commercial telegrams on long lines and cables, while Governments are fond of using cipher messages, usually in groups of five figures. An operator working on a keyboard can easily glance at an ordinary telegram and carry several words in his head while he is typing on the keyboard. With code and cipher messages this is not possible. This is obvious if we examine a fair average sample of a modern code message such as the following:—

"JYJEPLOLYG AYILUSTMA AVOKKOTUJ JYBOFOZNIT."

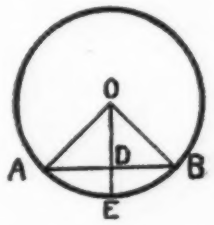
Clearly such messages must be very objectionable from a telegraphic point of view as they impose much greater strain on the attention of the operators than ordinary comprehensible messages. There is, therefore, more liability to error on the part of the sending operator, and there is no context to enable the receiving operator to judge whether he is receiving sense or nonsense. The sending operator has also to work much more slowly with such messages. The cost of transmission is therefore higher. In the case of printing telegraphs code messages are also objectionable, because it is difficult to say, without some experience, whether such a telegram is a code message or a case where the printing mechanism has got out of unison. Fortunately the record made by printing telegraphs when they get out of unison is to a certain extent characteristic, and the fault can in most cases be recognized by an experienced operator.

(To be continued.)

The Circumference of a Circle of Given Radius

By MABEL SYKES.

CARPENTERS and other tradesmen frequently wish to know the circumference of a circle of given radius. The accompanying graphic method is given in some



of the Self-education books as a substitute for computation:

Draw radii *AO* and *BO* at right angles. Draw chord *AB* and line *OE* perpendicular to *AB*, meeting circle at *E* and chord at *D*. To 6 times the radius add the line *DE*. The resulting line is approximately the length of the circumference.

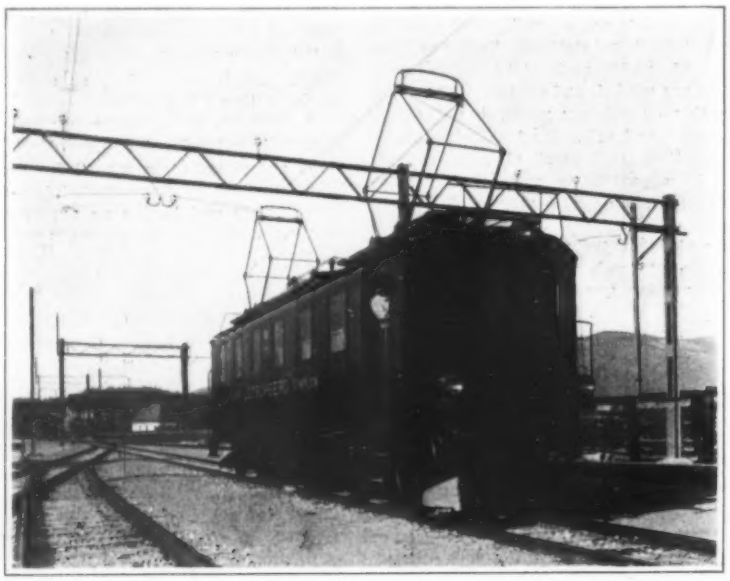
Compute the approximate per cent of error, using $\pi = 3.14159$. Answer, about 15 per cent.—*School Science and Mathematics.*

The Electric Locomotives for the Lötschberg Tunnel

A New Highroad Between Italy and Western Europe

By the English Correspondent of the Scientific American

The successful boring of the huge Swiss tunnel, 16,050 yards in length, under the Lötschberg, providing a new highroad between Italy and western Europe, has centered public interests in the arrangements for electric traction which are to be adopted on this railway. Though this tunnel is not yet in service, a section of the railway from Speiz to Frutigen has been in operation since 1901. During 1910 however steam traction was superseded by electricity. The system adopted is the single phase alternating current, 15,000 volts at 15 cycles on the contact line. The track is of standard gage, and when completed will connect Frutigen with Brigue on the Simplon tunnel line, the length of this section being 47 miles with a summit level of 4,100 feet.



The Two Thousand Horse-power Electric Locomotive (Swiss Design) Which Will Draw a Train of 310 Tons on a 2.7 Per Cent Grade at 26 Miles Per Hour.

As this line provides a direct route between Berne and Milan, and is intended to carry the whole of the through traffic between eastern France and Italy, heavy conditions of trunk rail road operation, such as exists on the Gotthard line, are anticipated. Consequently the conversion from steam to electric working was one beset with considerable technical difficulty on the single phase traction system with high contact line voltage, as at the time the decision was made there was no single phase electric locomotive exceeding 1,000 horse-power in operation.

In order to secure the very best possible results the authorities decided to extend manufacturers every opportunity of constructing and testing the most powerful locomotives ever designed, and for some time past trials and comparisons have been in constant progress. The whole of the electrical work has been carried out under the supervision of Mr. L. Thormann, consulting engineer, of Berne.

As a result of this action two electric locomotives have been acquired, one of Swiss, and the other of German origin, while three electric motor carriages for handling the passenger traffic on the existing line have been ordered. The latter eventually will be employed purely for local traffic, the electric locomotives being reserved for the haulage of all through-trains over the system. The motor cars are designed to seat 64 passengers and are driven by two motors, each developing 225 horse-power. They are capable of drawing a train weighing 135 tons on the Speiz-Frutigen section of the railway.

The Swiss electric locomotive constructed by the Oerlikon locomotive factory in accordance with their own patents, is the most powerful alternating current locomotive in the world, and by far the most powerful steam or electric locomotive in Europe. It is fitted with two 1,000 horse-power motors, the total output thus being 2,000 horse-power. It exerts a drawbar pull of 22,000 pounds, which is the maximum allowed in Europe according to international agreement, at a speed of 26 miles per hour. It will haul a train weighing 310 tons (exclusive of engine) at this speed on a 2.7 per cent grade. On the Gotthard Railway in order to handle a train of the same weight on a similar grade two steam locomotives are required to secure a speed of 22 miles per hour. Whereas the electric locomotive weighs 90 tons, the two steam locomotives weigh approximately 230 tons.

The German electric locomotive constructed by the Allgemeine Elektrigitäts Gesellschaft of Berlin on the Winter-Eichberg motor patents is somewhat less powerful, having a total output of 1,600 horse-power. Its haulage capacity is 250 tons, exclusive of locomotive, on the maximum 2.7 per cent grade at 26 miles per hour. The electrical equipment in this instance comprises two motors each developing 800 horse-power.

The trials with these engines were of great importance inasmuch as the conditions experienced on this railway are such as never have been submitted to electrical operation before. From Frutigen to Kandersteg, the northern entrance to the tunnel, a distance of 7.8 miles, the railway has to overcome a difference of 1,385 feet in altitude giving a grade of 2.7 per cent. At Speiz a capacious engine house has been erected for the accommodation of these two powerful locomotives together with the motor coaches. The comparative trials are to be continued so that by the time the tunnel is opened for traffic the railway may possess a number of the finest and most powerful electric locomotives it is possible to procure, to handle the heavy traffic which is certain to flow over this new connecting link between the Mediterranean and the North Sea.

International Association of Chemical Societies

On April 25th, 1911, there was called together in Paris a preliminary meeting of the delegates of the Chemical Society of London, the German Chemical Society and the Chemical Society of France, for the purpose of organizing an international association. The Chemical Society of London was represented by Messrs. Frankland, Meldola and Ramsay; the German Chemical Society was represented by Messrs. Jacobson, Ostwald, and Wichelhaus; the Chemical Society of France, by Messrs. Béhal, Haller and Hanriot.

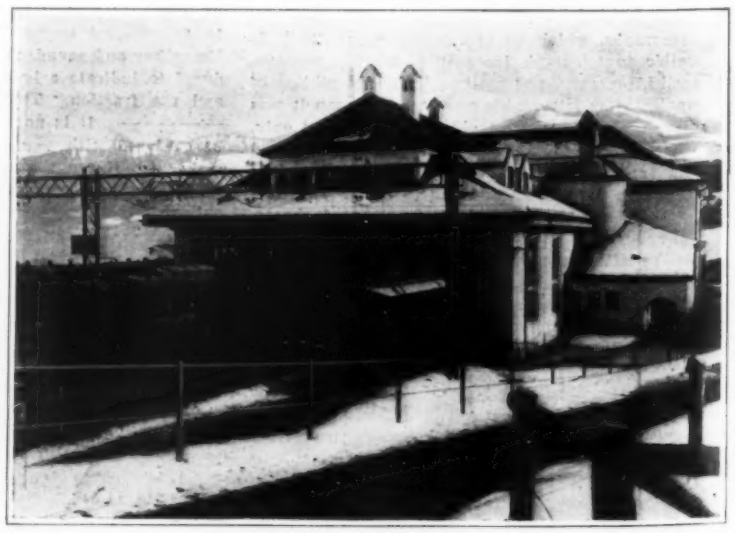
During the session it was voted to invite the American Chemical Society, the Chemical and Physical Society of Russia, and the Union of Italian Chemical Societies to be represented in the council and to name each three delegates. This invitation was duly presented to the Council of the American Chemical Society at their Indianapolis meeting and after careful consideration, on motion of Past President John H. Long, the following vote was passed.

The American Chemical Society views with favor the proposal to join with the chemical societies of London, France and Germany in the formation of an international association on the lines suggested in the provisional programme forwarded by Professor Ostwald, and the President of the American Chemical Society is hereby empowered to enter into correspondence on the details of the proposed organization.

Sympathetic Ink (green).—(*a*) Solution of nitrate of cobalt mixed with a solution of nitrate of nickel; the writing becomes visible after warming. (*b*) Write with a solution of arsenate of potash; bring up with a solution of nitrate of copper.

Sympathetic Ink (red).—Write with a very strongly dilute solution of aurous chloride of sodium; after drying, go over with a bath sponge, dipped in solution of tin salts.

The 1,600-Horse-power Electric Locomotive for the Lötschberg Railway.



The Electric Locomotive House at Spiez.

THE ELECTRIC LOCOMOTIVES FOR THE LÖTSCHBERG TUNNEL

The Evolution of the Umbrella

The Great Antiquity of this Commodity

By F. M. Feldhaus

THE invention of the umbrella was suggested by the broad leaves of tropical plants, and the first practical umbrella was an imitation leaf, made of some light fabric, and fastened to a stick. In oriental countries the umbrella has retained this primitive, fan-like form through many centuries to the present day. In those regions, however, rain is comparatively infrequent, and when it comes, it is so violent and long-continued that no umbrella would be of much use. Hence the umbrella was originally employed as a sunshade. These fan-shaped parasols are depicted in Egyptian inscriptions as ancient as the year 1170 B. C.

The modern umbrella appears to be an imitation, not of a single leaf, but of a widely branching tree. The inventor of the folding umbrella is unknown. A passage in the Greek play "The Knights," written by Aristophanes in the fifth century B. C., apparently refers to a folding parasol, and sunshades of this character are represented on antique Greek vases. This might seem to complete the story of the development of the umbrella, but that useful article has since undergone many changes and has been the subject of numerous laws and ordinances.

The Roman ladies adopted the parasol from the Greeks, as is shown by various passages in the works of Roman writers. The parasol was usually carried by a slave. The stick was made of bamboo, and the cover of variegated fabrics. The use of the parasol was not confined to women. The poet Claudianus complains that the effeminate Roman youths of the period (B. C. 399), instead of carrying off Sabine virgins, carried sunshades.

The first mention of the employment of the umbrella as a protection against rain occurs in the letters of Alcuin, a highly educated Englishman, who was the tutor and friend of Charlemagne. A letter addressed to the Bishop of Salsbury in the year 800 contains the words: "Alcuin sends the Bishop a 'roof' to protect his venerable head from the rain." Umbrellas were not generally employed for this purpose until many centuries later.

In the middle ages the umbrella was a mark of rank and honor. After the year 1176 a gorgeous umbrella was always carried before the Doge of Venice, whether the sun shone or not. The manuscript chronicle of the Council of Constance (1411-1418) contains a picture of the Pope's umbrella of state. The umbrella is depicted with a large triangular piece cut away, but this was done merely to show the head of the bearer and must not be taken as representing the reality.

From the fact that Leonardo da Vinci, in the year 1500, uses the word "tent" in describing his newly invented parachute, it is evident that the umbrella was then unknown in Italy. In France the umbrella, or parasol, was a rarity and an object of ridicule as late as 1598.

About this time parasols began to be used in Italy. The English traveler Thomas Coryate, in 1611, wrote that the Italian nobility carried silken screens, resembling small throne-canopies, for protection against the sun. The parasol was carried even on horseback, the stick being fastened to the rider's leg. The idea found favor in England and a parasol was car-

Umbrella Borne Before the Pope in 1414.

A Beau of the Ancient Régime With a Parasol.

An Antique Parasol. (From a Greek Vase.)

The Umbrella in Caricature.

A Slave Holding a Parasol Over Her Mistress. (From a Greek Vase.)

An Old Drawing (1819).

A Parasol of the Year 1670.

A Fountain at Heidelberg. (Engraving of 1619.)

An 18th Century Fop.

An Eighteenth Century Parasol.

THE EVOLUTION OF THE UMBRELLA.

ried on the stage, in a play produced in the year 1616.

The parasol appears to have been introduced into Italy from the East. I draw this inference from a passage in the description which the French engineer Salomon de Caus gives, in 1620, of the fountains with which he had adorned the park of Heidelberg Castle. Speaking of the fountain shown in an accompanying illustration, he says that the figure carries a sunshade or Indian head covering, also called a tiresol, from which water flows.

From the way in which the English philosopher Locke, in describing a visit to France in 1675, speaks of the parasols carried by French ladies, it is evident that the parasol was still almost unknown in England.

The description of Robinson Crusoe's umbrella in Defoe's famous work, which was published in 1719, probably did much to make the umbrella popular, as a protection against both sun and rain.

About this time rain umbrellas made their first appearance in England in a singular way, by being rented by the hour to students at Oxford and Cambridge. The umbrella-carrying students were laughed at, but not otherwise molested. Subsequently the philanthropist Jonas Hanwey strongly advocated the use of the umbrella and never appeared in public without a large and gaily colored umbrella, which he had brought from the East. He attracted crowds, and derisive epithets were hurled at him from the windows. Hanwey's force of character and imperturbable calm were required to make the umbrella popular. Others began to follow his example and, although his umbrella was long caricatured in the journals, the philanthropist, in his old age, had the satisfaction of seeing many umbrellas used in London by his fellow townsmen.

In the 18th century, also, inventors began to direct their attention to the improvement of the umbrella. The first rank in the production of umbrellas was soon taken by France, where a guild of umbrella makers was founded by Louis XV., in opposition to the turners, who claimed the right to monoplize the new industry. At this time appeared the "broken" umbrella, the stick of which was jointed, so that the cover could be inclined against slanting rainfall or sunshine, without holding the stick very obliquely. These umbrellas were sold in Paris, in 1755, for three or four dollars apiece.

In Germany, the manufacture of umbrellas was inaugurated in 1755, at Nuremberg. Soon, however, it was objected that carrying an umbrella advertised the bearer's inability to keep a carriage.

Between 1791 and 1843 sixty French patents were granted for improvements in umbrellas. These devices included umbrella-canes, telescoping umbrellas, umbrellas combined with opera-glasses and writing implements, and even the automatic umbrella, which opens when a button is pressed and which is regarded as a novelty to-day. In 1776 the Abbé Bertholon de St. Lazaro invented an umbrella provided with a lightning rod, for use in thunder storms. The stick contained a pointed metal rod which could be taken out and screwed on the top of the opened umbrella. The earth connection was made by means of a long piece of gilt cord which trailed on the ground and terminated in a metal ball. The ball and cord were carried in the pocket when not in use.

When the invention of the air balloon had revived interest in the parachute, the first experiments were made with ordinary umbrellas. In 1783 the physicist Le Normand accomplished the first successful descent, from the top of a tree, with two umbrellas, and in 1797 Gamerin descended from a balloon with the aid of one immense umbrella.

Even in the 18th century the umbrella had many opponents and formed a favorite subject of caricatures, in which it served as a mark of old-foggyism and stupidity. The absent-minded German professor who is always forgetting his umbrella has become a classical comic character, but an honorable one, for a man of science should be occupied with things more important than umbrellas.—*Die Gartenlaube.*

Protecting the Aeronaut from Lightning

How the Dangers from Atmospheric and Other Causes May Be Mitigated

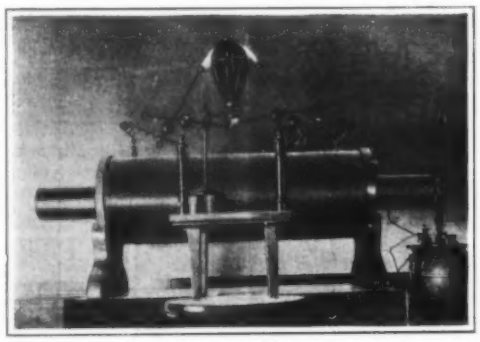
After thousands of balloon ascensions had been made during many years without a single fatal accident, 12 fatalities occurred in Germany alone in the past 18 months. These accidents can be divided into a few groups.

Although only a single fatality was certainly caused by lightning, the frequency of thunder-storms in summer emphasizes the danger which aeronauts incur from this cause. At present there is no known preventive except a timely landing. This, however, is not always possible, as was proved by an experience of Prof. Wiener, who discusses the perils of ballooning in an article in *Die Umschau*, which may be summarized as follows:

Prof. Wiener and another aeronaut, in an ascension made last May, were caught between two strata of clouds, between which flashes of lightning were formed in every direction except to leeward. Discharges also occurred between the lower stratum and the earth. The elevation of the balloon was about one mile. In these conditions the aeronauts considered it safer to drift onward than to land, or even to throw out ballast or open the valve. Two hours later they landed safely and were afterward overtaken by the storm. Prof. Wiener has since made some experiments which show plainly what happens when a spark strikes a balloon. If a spark passes completely through a collodion balloon, filled with hydrogen or illuminating gas, the gas may be ignited without explosion so that the balloon is quietly consumed. It is only when the balloon contains air mixed with combustible gas that explosion takes place. A balloon can even be traversed by sparks without being ignited. Sparks can be passed for a minute through small balloons made of Metzeler's balloon material without causing ignition and even collodion balloons can transmit a few sparks without burning. If the flow of sparks is so rapid and dense that it resembes a flaming arc it may directly ignite the material of the balloon.

Protection against these dangers can be obtained by surrounding the balloon and its car with a network of wires or Faraday's cage, which prevents the action of electric forces within it. Metzeler recently introduced a balloon material composed largely of aluminium, for the purpose of protecting the gas from the sun's rays. Experiments prove that this material is no better conductor of electricity than the ordinary balloon cloth. Even if it were possible to make a balloon of conducting material it would still be desirable to surround it with wires, as lightning follows the shortest path. If this is done, the conductivity of the balloon is of no importance. Owing to its greater strength, the wire netting need not be heavier than the hemp netting ordinarily employed. The balloon model surrounded by a wire cage allowed ordinary sparks to pass indefinitely, and a flaming arc for a short time, without being ignited. Fifteen seconds' direct contact with the flame was required to produce ignition. This experiment is illustrated by the upper spark-gap in the accompanying illustration. The ropes which support the car must also be made of wire and must completely surround the car.

It might be supposed that making the outside of the balloon a good conductor would rather invite danger from lightning. But although the ordinary balloon envelope is a fairly good insulator for low voltages it is unable to resist the high tension of atmospherical electricity. An electroscope charged to 2,000 volts is discharged in less than one second, when it is touched with a roll of balloon fabric about six inches long. Hence the balloon increases the electrical tension immediately above and below it, as much as it would do if it were a perfect conductor, but when the discharge occurs, its destructive action will be greater in proportion to the electrical resistance opposed to it.



Experiment Illustrating Protection of Balloons from Electricity by Wire Netting Around Bag and Filling Tube.

It might also be objected that the Faraday's cage would be a source of danger to its inmates. The discharge, however, passes chiefly through the wires, and only partial or inductive discharges can strike the inmates. Many persons have been struck by lightning without permanent injury. It is evident that the Faraday's cage can be applied still more easily to aeroplanes.

Even when a balloon is thus protected from lightning, it is exposed to another danger from atmospheric electricity. A balloon has been ignited and consumed by small sparks produced by touching the escape valve after landing. This valve and the filling tube, which normaly is open during flight, are the two places in which the gas can come into contact with the air, and therefore need special protection. The simple and long-known device employed in the Davy safety lamp can very well be applied to this purpose. The safety lamp protects the miner from the explosion of fire damp. The flame of the lamp is surrounded by a fine wire netting which conducts heat so well that the temperature required to ignite the gas cannot be produced on the outside. Any gas which enters the lamp burns quietly without causing a general explosion. Both the escape valve and the filling tube of the balloon, therefore, should be surrounded with a fine netting of copper wire. This affords protection also from lightning in certain cases.

An electric discharge may be precipitated by pulling the valve cord in a strong electric field, as, according to Paschen's experiments, the striking distance is smaller in hydrogen than in air. This can easily be proved by connecting a Bunsen burner with one pole of an induction coil and raising a metal point connected with the other pole so high above the burner that no sparks pass. The flow of sparks recommences when the gas is turned on. If the burner is surrounded with a wire netting the gas burns only on the outside.

When sparks are allowed to pass beneath the open filling tube of a balloon model, the balloon is sometimes ignited; but if the tube is protected by a wire netting, a flaming arc can play upon the netting for a minute, without igniting the gas. (See the lower part of the illustration.)

A second danger, which has already caused one fatal accident, is due to passengers being thrown out of the car in landing. Throwing out a bag of ballast weighing 35 pounds causes a balloon of moderate size to rise suddenly more than 300 feet. Hence, the loss of a passenger weighing 150 pounds would send the balloon up 1,300 feet. If all of the ballast has been expended the remaining aeronauts will be likely to have a rough landing. The pilot usually pulls the rip cord in order to empty the balloon more quickly. The vent may, however, be closed by the wind in some positions of the balloon. If one or more persons are at the same time thrown out, the balloon may make an upward leap of hundreds of yards. The vent will then open spontaneously, allowing the gas to escape very quickly so that the balloon falls like a stone. This was the combination of circumstances which presumably caused the death of Prof. Abegg. In landing, three persons were thrown out of the car, the balloon rose nearly a mile, and then opened wide along the rip vent and fell as described above.

Such a mishap could be prevented by making it impossible for persons to be thrown out in landing. For this purpose it is merely necessary to surround the car with a net either permanently or just before landing. This net will not prevent the passengers leaving the car with sufficient rapidity. Every aeronaut knows that, for the sake of the safety of his companions, he must not leave the car before the pilot has given the order, and the pilot must not give the order until the balloon is sufficiently evacuated and has completely lost its buoyancy and horizontal velocity. If this is the case the passengers can leave the car at their leisure.

A balloon which has opened in the air, bursts in consequence of excessive internal pressure, or even been exploded by lightning, is not necessarily lost. This was proved experimentally as long ago as 1838 by the bold American aeronaut, John Wise, who tied the filling tube of his balloon and rose to a height of 13,000 feet, where the balloon burst. It fell at first with frightful velocity, but the air pressure thus produced beneath it soon turned the lower half of the balloon inside out, and pressed it against the upper half, the two forming an inverted bowl, which acted as a parachute and brought the daring aeronaut safely to land. Wise repeated this experiment with the same result. At the Berlin aeronautic contest in 1908 Holland and another American repeated Wise's experiment. The balloon

fell from a considerable height to the roof of a house. The persons who hastened to the aeronauts' aid found them in the act of photographing their balloon. When the balloon burst they had cut the cord of the filling tube and thus allowed the balloon to assume the form described above. This action is necessary because otherwise the filling tube is held down by the cord and the lower part of the balloon cannot be driven upward. Hence it is probable that Prof. Abegg would have escaped death if he had cut the cord. He was probably injured at once, so that he could not do so. It would not be difficult to devise a means of cutting or loosing the cord automatically when the balloon attains a dangerous velocity of fall. Experiments have been made with an apparatus which in this juncture warns the aeronaut to throw out ballast, and it would be just as easy to cast loose the cord by an automatic electromagnetic device.

Another source of danger is insufficient buoyancy at the start. Last Spring the balloon "Pommern" collided violently with a chimney, injuring some of the passengers and contributing largely to its subsequent disaster. At the start the balloon rose about 100 feet, but was swept downward by a gust of wind. Such accidents can and must be avoided. The buoyancy of a balloon can be approximately calculated, and when the velocity of the wind is known, the distance from the starting place at which a given height will be reached can be determined. An ascent should not be attempted in violent or variable winds in the vicinity of high buildings. A more exact and mechanical method of starting, in which the buoyancy is measured by a spring dynamometer, appears possible.

A last group of casualties is occasioned by dangers voluntarily incurred, usually for the sake of winning a prize or wager. A balloon flight over the open sea is always perilous. The Baltic may be crossed by an aeronaut thoroughly acquainted with the prevailing winds, but attempts to cross the North Sea from Cuxhaven to England are extremely rash at all times. This feat was attempted by some of the participants in the Gordon Bennett contest of 1908 and also in November, 1910, with fatal results, by the balloon "Saar." A wind blowing from Cuxhaven in the direction of England is usually deviated to the right at sea by the earth's rotation, which produces a greater effect at sea than on land, owing to the diminished friction between the wind and the earth's surface. This elementary law of meterorology must be reckoned with in attempting this feat.

An aeronaut who, for the sake of making a record, prolongs his journey into inhospitable regions, especially in winter (as in the flight of the "Luna" from Dresden to Finland), or who throws out so much ballast that he is unable to make a safe landing in a mountainous district, voluntarily risks his life. Rashness of this sort might, perhaps, be checked by excluding from prize distributions every aeronaut who has met with an accident in his flight.

A gratifying contrast to such foolhardiness is afforded by the combined prudence and enterprise exhibited by Capt. von Abercron, who, in last year's Gorden Bennett contest started from St. Louis and landed safely in the wilds of Canada.

All of the fatalities of the last few years appear to be due to the causes enumerated above, which can be eliminated by prudence and protective devices. A normal balloon trip in good weather, with a careful experienced pilot, is not a very perilous undertaking. According to a compilation made in 1906, 1 death and 36 more than trivial injuries resulted from 2,061 balloon flights in which 7,570 persons took part. In round numbers, one person in 8,000 was killed and one in 200 was injured. In the unlucky 18 months just passed 12 deaths and 48 serious injuries resulted from 2,633 flights with 9,000 persons. In round numbers one person in 100 was killed and (as before) one in 200 was injured. Every year 112 persons are killed and 4,500 are injured by vehicles in the streets of Berlin. Assuming the population to be 2,000,000, we find that death or injury is about as likely to result from an average balloon trip (excluding those of the last 18 months) as from being run over, in 2 1/3 years or 24 years residence in Berlin. The danger is very much smaller in normal flights in favorable weather. It can be still further diminished by the adoption of the devices and suggestions here presented and the realization of Prof. Assmann's project of transmitting weather signals regularly to balloons by wireless telegraphy.

How to Determine the Day of the Week of Previous Dates

By BEN M. JAQUISH.

EACH country, two thousand years ago, had its own era, which was based upon its independence, the date of the accession of some king, a decisive battle, or some other important event. The beginning of the Roman era was the founding of Rome. Although this event is supposed to have taken place 753 B. C., Roman dates were in use long after what is now known as the beginning of the Christian era. The Julian calendar, introduced by Julius Cæsar in 46 B. C., was in general use throughout Europe until 1582, and is still in use in Russia and Greece. The early Christians started a new or Christian era based upon the *death* of Christ, but this was changed in 533 A. D., when Dionysius Exigius, a Roman monk, fixed the beginning of the Christian era at the *birth* of Christ, which he regarded as having taken place in the year of Rome 754. Other early Christians as well as modern Biblical scholars place this date at 750. However, the Dionysian era is the one now used, so the birth of Christ took place 4 B. C.

The beginning of the year, as well as the beginning of the era, has been subject to change. In England, down to 1066, it was March 25th; 1066 to 1155, January 1st; 1155 to 1751, March 5th; and finally, by the Calendar Amendment Act, which took effect in 1752, the beginning of the year was established as January 1st.

The year of the Julian calendar consisted of 365¼ days. There were three successive years of 365 days each, and a fourth of 366 days. Inasmuch as the solar year is about eleven minutes less than this, counting one year in every four a leap year, is too many by about three years in 400. To correct this error, Pope Gregory XIII., in 1582, with the assistance of Clavius, an astronomer, prepared the Gregorian calendar. This provided for the dropping of ten days, making October 5th, October 15th. It also provided that only the centuries divisible by 400 should be leap years. In France, in the same year, December 10th became December 20th. Catholic countries, in general, adopted the Gregorian calendar at once; Protestant countries, later. England adopted this calendar in 1752, when September 3rd became September 14th. In the Protestant States of Germany it was not wholly adopted until 1774.

With these facts in mind, a method for determining the day of the week any day of the month falls on becomes an easy matter. If there were 364 days in every year, the same day of the month would always fall on the same day of the week; e. g., if January 1st in the year 1 fell on Friday, it would fall on Friday every other year. But as there are 365 days (not including leap years) the day of the week of any particular day of the month comes one day later each year; and in 1200 A. D. it will be 1200 days later than in the year 1. However, there are leap years, so the day of the week will come 1200 days plus 1200 ÷ 4 days later. And for any other date the first day will move ahead as many days as the date is later than January 1st. With every advance of 7 days of the week any day of the month again falls on the same day of the week as at the beginning; so, dividing the total number of days a day of the week has advanced by 7, we get a whole number of cycles, with a remainder which indicates the day of the week. A remainder of 1 means Friday; 2, Saturday; 3, Sunday; 4, Monday; 5, Tuesday; 6, Wednesday; 0, Thursday. Of course this applies in the English calendar only until 1752. After that date, in the eighteenth century, by dividing by 4, eleven too many leap years* are obtained, hence, eleven days must be subtracted; in the nineteenth century, twelve days, and in the twentieth, thirteen days. If the date is later than February 28th and falls on a leap year, by dividing the year by 4 the extra day is counted, and February must be counted as having only 28 days. If the date is before February 28th, the division by 4 gives one day too many, and must be subtracted from the total. A few examples will illustrate this method.

On Friday, October 12th, 1492, Columbus discovered America.

1492
373 = 1492 ÷ 4
285
7) 2150

1492 is a leap year, and the number 373 includes February 29th.

307 — 1 = Friday.

January	31
February	28
March	31
April	30
May	31
June	30
July	31
August	31
September	30
October	12
	285

This method assumes that in 533 A. D., when Dionysius established the year of Rome 754 (date of the birth of Christ) as the beginning of the Christian era, the date he accepted made January 1st, 1 A. D., come on Friday. Because of one day more than 52 weeks in a year, this day has moved ahead in 1492 years 1492 days, plus 373 days due to 373 leap years, and October 12th has moved ahead 285 more days, or a total of 2150 days. But as every 7 days brings it back to Friday, dividing by 7 gives 307 cycles of 7 days each, with a remainder of 1, showing that October 12th, 1492, is the first day of the 308th cycle, or Friday. This method applies to any English date before September 3rd, 1752. For any later date in the eighteenth century 11 days must be subtracted from the total; in the nineteenth century, 12 days; and in the twentieth century, 13 days.

December 14th, 1799, Saturday.—Date on which Washington died.

1799
449 — 3
348 = Number of days from January 1st to December 14th.
2596
11 = Eleven days dropped in 1752.
7) 2585
369 — 2 = Saturday.

January 21st, 1892—Thursday.

1892
473 — 0
21
2386
12
2374
1
7) 2373
339 — 0 = Thursday.

473 includes February 29th, 1892. As January 21st comes before February 29th, this extra day should not be counted. In this case I have made an extra subtraction before dividing by 7. Ordinarily the correction number, 11, 12, 13, would be increased by 1.

12 = the 11 days dropped in 1752, and one day included in 473. By dividing 1892 by 4, 1800 is counted a leap year.

January 30th, 1910.

1910
477 — 2
30
2417
13
7) 2404
344 — 3 = Sunday.

The following are a few well-known dates in English, French, and American history and events of the crusades, that may be used in verifying this method:

Saturday, October 14th, 1066.
Monday, February 14th, 1099.
Saturday, July 4th, 1187.
Monday, May 6th, 1191.
Wednesday, June 17th, 1215.
Friday, May 18th, 1291.
Sunday, June 8th, 1376.
Monday, September 19th, 1356.
Friday, April 29th, 1429.
Tuesday, October 12th, 1428.
Sunday, March 1st, 1562.
Sunday, August 24th, 1572.
Wednesday, February 25th, 1601.
Tuesday, January 30th, 1649.
Sunday, March 8th, 1702.
Thursday, July 4th, 1776.
Friday, April 12th, 1861.
Monday, September 19th, 1881.
Friday, September 6th, 1901.
Thursday, February 3rd, 1910.

* The eleven days dropped by Pope Gregory.

Determining the Salinity of Sea Water

IN an article published in the *Comptes Rendus*, A. Berget describes a refractometer for determining the salinity of sea water. As the determination of the salinity from density measurements by means of aerometers is hardly possible on board ship, total reflection refractometers of Pulfrich and of Abbe had been tried. Berget finds a simplified Féry refractometer more convenient; the determination is rapid and a few cubic centimeters of water suffice. In experiments with solutions of NaCl, the salinity increasing by 0.005 from 0.005 to 0.045, the refractive index rose from 1.333804 to 1.34050 at 16 deg. C. according to a straight-line law; experiments with diluted sea-water were also satisfactory.

A New View of Roman London*

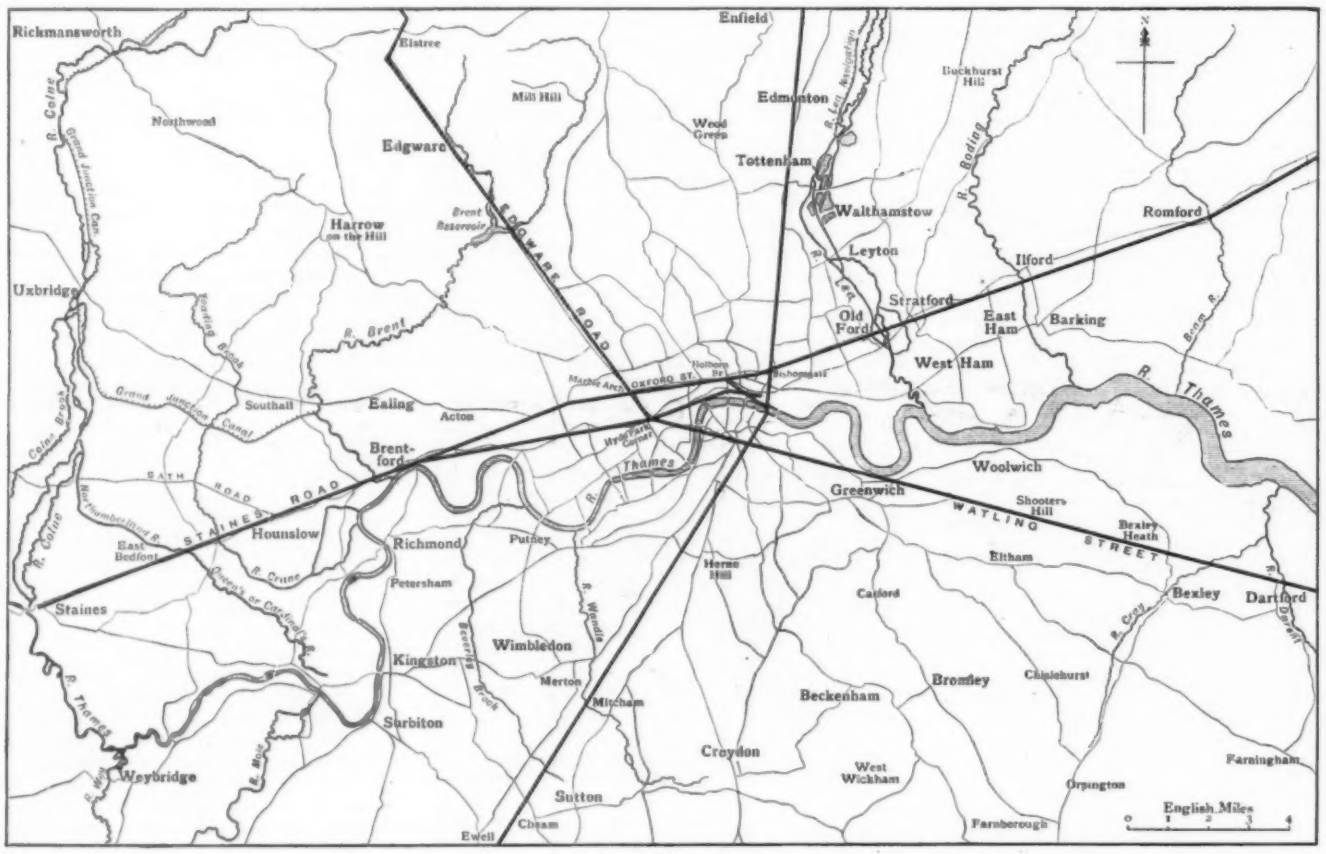
The Highways Laid Down During the Roman Occupation

By Reginald A. Smith, F.S.A.

BRITAIN was in contact with Roman civilization a century before the conquest under Claudius, and that period of respite sufficed to show the natives whom they had to fear, and the best means of defending their shores and estuaries against a surprise attack. Till recent years the attainments of the ancient Britons have been strangely underestimated, and without exaggerating their capacity we may assume that their standard of civilization was little below that of their Romanized neighbors across the Channel.

That chariots were extensively used by the Britons in warfare is clear from the narrative of Cæsar, and the large number under the command of Cassivellaunus in B. C. 54 implies an elaborate road system at least in his own dominions, and therefore along the north bank of the lower Thames. One of the principal duties of such a force would be to keep a watchful eye on the river traffic; and that Roman boats about sixty feet long ascended the river at least as far as Westminster two or three centuries after the time of Julius is shown by the recent discovery of such a vessel below ten feet of river mud on the site of the new County Council Hall. To watch the river it was necessary to have a regular roadway on high and dry ground as close as possible to the water, and this was practicable only on the north bank near London.

East of the Lea, and a good way beyond London on the south, the banks would be useless for such a purpose; and it is interesting to find the remains of an ancient road running east and west on the brow of the hill just above what is now London Bridge. When that road was first engineered we can only surmise, but it was certainly built or rebuilt by the Romans, for an entire section of it was made and published in 1833 during alterations for the bridge-approach in what is now Cannon Street, but was then called Great Eastcheap. A gravel road 16 feet wide, supported by two walls 7½ feet high, was found about 3 feet below the modern roadway pointing to London Stone on the west and apparently to Aldgate on the east, but it has not been traced east of Gracechurch Street. Narrower by 8 feet than Watling Street, as discovered in Edgware Road, it lacked the layer of flints that distinguished the Roman military roads; but there is no doubt of its Roman construction, as the containing walls have bands of the familiar tiles between stages of Kentish ragstone. The position, however, suggests an earlier British origin, and if this road were to enable horsemen to patrol the river and give notice of any hostile approach by water, then we must imagine it continued, at least westward, along the brow of the steep northern bank, and crossed the Walbrook, which was at that time a broad tidal river running into the Thames at Dawgate Hill. That there was a bridge here in Roman times is practically certain, as the sill of a bridge, stout oak piling and lumps of herring-bone pavement have been found just at this point. The Walbrook once crossed, the road would naturally proceed along the south side of St. Paul's and down Pilgrim Street to the Fleet, which was, no doubt, crosed by a ferry. Its subsequent course would be quite conjectural were it not for the occurrence of three Roman burials that exactly indicate a line that is more than probable on other grounds. It is common knowledge that the Romans laid out their cemeteries along their main roads, but the evidence of burials with regard to roads has been rather neglected in this country, and it is surprising to find how useful these scattered and accidental discoveries are in the neighborhood of London. Indeed, the roads for which there is least presumptive evidence are the best attested by burials along their course, and the present instance is, perhaps, the most illuminating. A stone coffin was found in Howard Street, Strand, and cinerary urns under the portico of St. Martin's-in-the-Fields and at the west end of Cockspur Street. If the theory holds good, a line drawn between these sites should indicate the course of a Roman high road, and the only line that satisfies the conditions runs from Bridge Street, opposite the foot of Pilgrim Street, through the Temple, under Somerset House, between this hall and the Strand, past the National Gallery on the north (and higher) side of Trafalgar Square, under George III.'s statue and the Waterloo monument, across the south side of St. James's Square and the west end of King Street, to enter St. James's Park a little above the bandstand, whence still in a straight line it would follow the high ground to the Tyburn valley. Crossing the stream—no doubt by a bridge as the banks are somewhat steep—it would, in a few yards, reach the south end of Park Lane, and Hyde Park Corner has always been an important landmark. Nor need we give up hope of following it still further, for though connected with the Thames it could not well have crossed the low and then swampy ground south of Knightsbridge. The drainage of Pimlico is one of the wonders of London, but of quite recent date; and farther west the bends of the river inclose flat areas then, if not now, liable to floods; but a road was practicable on fairly high ground to Brentford, which there is reason to believe was the objective of this ancient highway. The former importance of this town may be partly explained by a ford over the Brent and by the fact that here is a stretch of gravel in the Thames bed which made it possible to ford the river at low tide in the days before steamboats rendered a deeper channel necessary. A few years ago Mr. Montagu Sharpe convincingly argued that here was the spot where Cæsar crossed the Thames, and the existence of a large number of stakes in the north bank is in full agreement with Cæsar's own account of the crossing. For him there was only one ford, and that a difficult one, to take him into the territories of Cassivellaunus, and here, if anywhere, would be a British stronghold reached by well-kept roads. The supposed road from Brentford to Hyde Park Corner is practically in the same line as the section from the latter point to the Fleet, and in my opinion both belong to a system elaborated by the ancient Britons for their own safety and convenience. It may be remarked in passing that the road west of the Fleet, which seems to be marked out by the burials with mathematical precision, exactly coincides with the Terrace of the Inner Temple. The whole group of buildings is evidently based on that line, while the Strand frontage is ignored; and if the Terrace is, in fact, a remnant of this early highway overlooking the Thames, the curious alignment is easily explained.



ENVIRONS OF LONDON WITH MAIN ROMAN ROADS.

The advantages secured to the Britons by this road would also appeal to the Romans, to whose engineering skill and thoroughness may be attributed the straightness and stability of this secondary highway. Another road of more importance may also have been laid out before the Roman Conquest, but its length and directness point unmistakably to Roman initiative, and at least near London may, without much hesitation, be assigned to the latter half of the first century. Here, as in other cases, a clue to the original course of the road may be gained by producing the straight lines that still exist outside London, but a word of caution is necessary as to the name of Watling Street. In Kent there is no ambiguity, but in the metropolis the presumed original highway of that name must be clearly distinguished from the street that runs east from St. Paul's to Queen Street. The latter will be discussed in another connection, but at

* Paper read before the Society of Arts and reprinted from its *Journal*.

first the Roman highway from the Kentish ports to Chester seems to have avoided the city and crossed the Thames at Westminster. And here may be interpolated an interesting piece of history that seems to be capable of an exact interpretation on these lines. A stage in the conquest of Britain was marked by the arrival of the Emperor Claudius, for whom a victory had been arranged by Aulus Plautius in A. D. 43. The historian Dio Cassius was born a century later, but probably had access to documents which taught him as much about the British campaign as the ordinary Englishman knows about Trafalgar or Waterloo; hence the outlines of his story at least may be taken as correct. After the Romans had crossed a river that the Britons thought would stop them, the latter, he says, retreated to the river Thames, where it debouches into the ocean and becomes an estuary at high tide; and easily passing it, as they were well acquainted with those parts which were firm and fordable, were pursued by the Romans, who failed to overtake them; but certain Celts—who even under arms were accustomed to swim with ease over the most rapid rivers—again swimming over, and others passing a little higher up by means of a bridge, they attacked the enemy on every side and cut off many; but, rashly pressing on the remaindor, they wandered into the pathless marshes and lost many of their own soldiers. This story is circumstantial enough to be credited, and there is no doubt about the river being the Thames; but the site of the engagement has been disputed. The problem is to find a short stretch of the river which at one end was just fordable and bordered on the estuary—that is, suddenly spread from a confined bed into lagoons or marshes covered at every tide—and at the other was narrow and shallow enough to be crossed by a native bridge before the Roman occupation. If estuary implies salt water the problem is insoluble, but if interpreted as above the words are in striking accordance with the report of the Geological Survey. Mr. Whitaker states that London is the first spot where vessels going up the river would find a narrow low-water channel close against ground of the most favorable kind for permanent occupation, ground, indeed, yielding every advantage that our distant forerunners could have wished for; and their choice has been fully ratified by succeeding generations who have built up the great city. Above London there are only narrow strips of alluvium, the river flowing between gravel banks and necessarily keeping to a narrow channel. Below London, however, the scene was far different from what we see to-day. The river flowed through mud plains covered with water at high tide only, and at low tide showing broad spreads of treacherous mud, as at Southend at the present day. Firm land was only touched at some of the bends in its course, as at Greenwich and Woolwich. The Lea valley may be taken as the limit of low ground on the north bank, and the river at the Custom House may well have been fordable at low tide, though dangerous to those not familiar with the crossing. Improbable as it may seem to-day to anyone standing on London Bridge, it is nevertheless supported by facts that came to light during the demolition of old London Bridge. Sir G. B. Airy, late astronomer royal, stated half a century ago that the depth of the foundations of the piers was good evidence of the depth of the river at old London Bridge. It appears from a published cross-section that the lowest part of the rubble, on which were laid the wooden sleepers supporting the masonry, was only from two to three feet below low water. It is certain, he says, that this could not be higher than the general bed of the river, and it probably would be lower. Some channels naturally would be deeper than the general bed; and these, when the tide had risen a little, would make the operation of fording very dangerous.

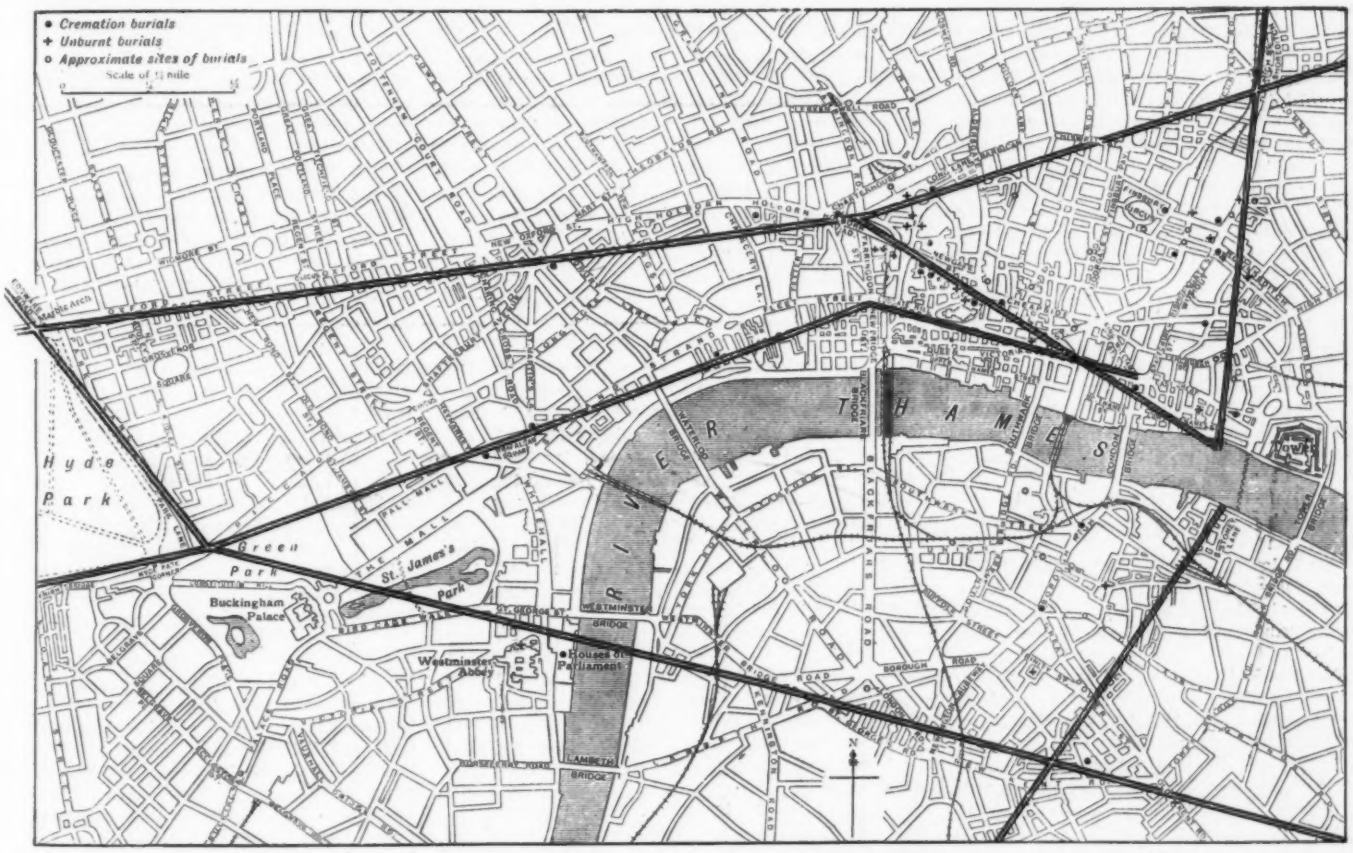
If the dangerous British ford was at or near the Custom House, the bridge was not far off; and in view of the course of Watling Street there can be little doubt that the bridge was at Westminster, which would be about 2¼ miles above the ford or, as Dio says, a little higher up. That the construction of a simple bridge here would not baffle the ancient British is suggested by the fact that in 1846 a man forded the river at this point, as recorded in the *Gentleman's Magazine*.

Toward the British bridge, therefore, at Westminster the highway was directed, and a straight line in continuation of the fine stretch of Roman road on Shooter's Hill skirts the river at Deptford, crosses the Thames a little south of the present Westminster Bridge, and reaches the southern end of Park Lane, where it may be presumed to have turned into the line of Edgware Road; for a prolongation of that road would almost coincide with Park Lane, and naturally stop at what we have already supposed to have been an important road-junction. This, at any rate, is the solution suggested by a consideration of outer London, and by the observance of the Roman rule that roads run straight unless turned aside by serious obstacles. The Edgware Road is an excellent example, running in a straight line till compelled to swerve in ascending Brockley Hill; and the onus of proof lies on those who would make the Roman roads crooked without weighty and sufficient reason.

Several objections might be raised to this route, and some may be briefly answered. The avoidance of London may only show that the city was not at the time important enough to divert the road, or possibly an avoiding line was chosen for through traffic, just as on a modern railway system. At first London was not a commercial center, and Westminster also had a gravel subsoil, at least in the line of the road, and the additional advantage of a bridge. The line as restored passes very near a bend in the river at the mouth of Deptford Creek, and though some engineering difficulties would be encountered, this point of contact would furnish a site for a dock. Goods could be conveyed to this point by water more easily and more cheaply than by the road from the ports of Kent, and could here be put on shore for transport inland; and we shall see that London had its own docks later, on the north bank, a little farther up the river. Leaving Deptford, the highway struck right across what is thought by some to have been a huge lagoon or morass in the Roman period; but this view of South London is clearly incorrect, as Roman remains and especially burials indicate dry and firm conditions in an area that has a subsoil mainly of gravel. Most of the burials along this line are not definitely located, but those at the Deaf and Dumb Asylum in the Old Kent Road and west of Deverell Street exactly accord with this theory, and flank the road on either side. Passing about 130 yards north of the Elephant and Castle, the line reaches the river near the middle of St. Thomas's Hospital, and the vicinity of Stanegate (Stonegate) is significant, as probably preserving the memory of an approach to the river that was paved by the Romans. Stanegate is also the name of a Roman road near Vindolana (Chesterholm), just south of the Roman wall in Northumberland.

In the fourteenth century, when there were probably clearer traces of the Roman highway than there are to-day, there lived a monk named Higden who was connected both with Westminster and Chester, and had therefore probably traveled over a great part of the Watling Street. In the Polychronicon he described this road as crossing the Thames to Westminster and beyond, westward to a point at which it turned toward St. Alban's. That is at least what I consider a fair reading of the text which has been variously translated and interpreted. The critical words are *ad occidentem Westmonasterii*, which I take to imply a continuation to the western part of Westminster, and not a passage of the river at a point which lay on the west of Westminster. The map shows this would be an absurdity, as the Thames, for about half a mile above and below Thorney, flows from south to north, and Westminster in those days meant Thorney. On the other hand, Higden's words seem to agree absolutely with the route suggested above.

It was long ago pointed out by Dean Buckland that a bank of gravel stretches from the river westward almost to Buckingham Palace, and the builders no doubt availed themselves of this firm foundation for their road, which, however, had to cross some low-lying and, at that time, marshy ground before reaching the bottom of Park Lane. The lake in St. James's Park is a relic of these conditions, but had not always its present form. The road would cross about halfway between the bridge and the fountain, and to-day a stretch of lawn between two banks may mark its



COURSE OF ROMAN MAIN ROADS THROUGH LONDON

original course. In the Green Park also may be observed a cutting in the west bank of the Tyburn—rather steep on the north side of the park—that lies in the direct line to the supposed junction in Piccadilly.

From the map it is fairly obvious that Park Lane represents a southern continuation of the Roman road that practically coincides with Edgware Road, and from the elbow in Piccadilly we may suppose the road ran in a straight line to Brockley Hill. Nor is this a mere supposition or tradition; the actual road was struck in 1902, almost exactly in the middle of Edgware Road, opposite Seymour Street. Another discovery, unhappily not so precise, seems to shed fresh light on the intersection of Roman roads at the Marble Arch. In Rocque's map of 1746 is marked the position of a stone against which condemned soldiers were shot inside the park, civilian criminals being executed at Tyburn gallows just outside. It was described as a Roman "geometric" stone, that is, a stone set up as a landmark by road-surveyors, and probably inscribed with distances to various points. The intersection near the Marble Arch of two important Roman highways (the original Watling Street and that from Romford to Staines) would fully account for the position of the stone which, on the map, lies in the middle line of the avenue. It was to be seen before 1822, a few yards south of Cumberland Gate, but during alterations of level in that year for a new gate it was covered up, being too deeply embedded for convenient removal. This in itself is extremely significant, and will be discussed later in connection with London Stone, from which it is about 3½ Roman miles distant.

The east-and-west road is characteristically Roman in its defiance of minor obstacles and adherence to the straight line, but did not actually pass through Roman London. It led from Essex across the Lea to Holborn, along Oxford Street and Bayswater Road over Notting Hill to Brentford, where it joined the British highway already noticed, and thence to Staines and across the Thames to Silchester and beyond. Though its course through Essex and west of Holborn is fairly well established, the intervening portion that skirted the north wall of the city is more conjectural, and it is only in the last few years that indications of the line have been noticed. Even without this fresh evidence, one could guess at its position by producing the line that is fairly clear from Romford to Stratford Town Hall, and this would pass through Old Ford, under Bishopsgate goods station, Finsbury Square and Smithfield to Holborn Viaduct. Beyond this the direction is slightly altered, but another long stretch takes us in a straight line to Notting Hill. That such was indeed the original route is virtually proved by the following considerations. About four years ago lumps of tiles, cemented together to form a herring-bone pavement of a common Roman type, were dredged up by the Lea Conservancy Board in the Lea just below the lock at Old Ford, exactly at the point where our imaginary line would cross the river. That there was once a ford hereabouts is clear from the name of the district, but so far as I am aware its exact position had not been previously determined. It was at Old Ford that the Lea was generally crossed before Bow Bridge was built, about the middle of the twelfth century; and it is recorded by Lysons that Matilda, wife of Henry I. caused two bridges to be built over the Lea and its tributary, the former known as Bow Bridge and stated to be one mile from the old ford. The two points are, in fact, just half that distance apart, and the Roman ford approximately coincided with the line of Iceland Street, a little below the crossing of the outfall sewer. At least two burials at Old Ford station, and another behind the police station at the eastern end of Bethnal Green Road, seem to have been connected with this road, which farther west runs straight across Moorfields, a fact that might at first sight cause some misgivings. The Roman wall round London, inclosing an area of about 360 acres, was built across the Wallbrook, then a considerable tidal stream which passed through gratings in the foundations. Either through neglect or of set purpose the citizens allowed these gratings to be clogged with river weeds and refuse, as proved by excavation in our own time, and the result was that the water was dammed back outside the wall, and in time spread over what was later known as Moorfields. This area was skated over in the time of Henry II., and remained a waste till drained and turned into a pleasure garden early in the seventeenth century. It was suggested by Stukeley that the morass was deliberately formed to protect the city on the north, but in any case we must assume that before the wall was built Moorfields was firm and dry, with a gravel soil capable of bearing a main Roman road, as is shown by a child's burial there containing a gold coin of Salonina, wife of the emperor Gallienus (253-268). Though most authorities are in favor of the fourth century, it is conceivable that the wall was already built in the middle of the third, but the morass cannot have been in existence when the interment took place. Some time after that date the east-and-west road must have been ruined by the swamp, and a way round must have been devised. The nearest high ground north of Moorfields is marked by the line of Old Street, and in this thoroughfare, where it is joined by Goswell Road, two Roman road-levels one above the other, were found in 1867 during some deep excavations which revealed medieval roads above. This diversion enabled traffic to pass easily between Holborn Bridge and Norton Folgate, without going through the city. At Smithfield interments of both kinds (cremations and inhumations) have been found in considerable numbers, and here, as elsewhere, the angle between two main roads seems to have been a favorite burial-ground. Other burials farther west give a clue to the position of the road after the Fleet was crossed by a bridge, probably at the bottom of Snow Hill. In fact, the *Gentleman's Magazine* of 1750 records that in digging the foundation for Holborn Bridge, remains of the Roman military way were discovered pointing directly to Newgate. A straight line from here to the Marble Arch does not coincide with Holborn and Oxford Street, but passes burials on its north near St. Andrew's Church, at the Birkbeck Bank, and another on the south in Endell Street. This line includes part of High Street, Bloomsbury (which was the principal street here till New Oxford Street was opened a few years ago), and gradually approaches Oxford Street as it proceeds westward.

The two main roads that remain to be considered seem to have met on the Thames bank at a spot always of special importance to London, and probably the site of the first wharf on the north bank of the river. To determine this point we may first produce the lines of recognized Roman roads in the suburbs and then test the accuracy of the method by a survey of the archæological and historical evidence.

From Ware southwards to Edmonton there can be traced on the map a line that is continuous with the recognized Roman road that coincides with the highway from Edmonton through Tottenham and Kingsland to the city, and the presumption is therefore that the Roman north road from the Thames ran straight from the river at least as far as Ware. Its course would have been under the old Custom House, a little to the east of the present building, and about 100 yards west of the Thames subway at the Tower. Opposite this is the point where the line of Roman road known as Ermine Street, on the Leatherhead Downs, would, if produced, strike the Thames, and this coincidence strengthens the belief that these roads were intended to join at a recognized river crossing where the Romans doubtless erected a bridge on the site of what seems to have been the lowest ford on the river in British times. It is true that a distance of sixteen miles, between the track on Leatherhead Downs and the river, has to be covered by conjecture, except for a fragment of the road at Ewell; but if the straight line was preserved over such difficult ground as the Downs above Mickleham, it may justly be inferred that no deviation would occur on the lower ground toward London, and that the point aimed at on the river was in a line with the surviving remnant on the Downs. Some such connection must be found between these two portions of the Ermine Street (called Stane Street between Chichester and Dorking, and deflected by Box Hill), and the course suggested is not only the most obvious but is supported by a certain amount of archæological evidence. That the Roman road did not coincide with Borough High Street is proved by the discovery of a Roman tesselated floor right in the center of the last; and excavations in the city have made it fairly certain that the road did not swerve on entering the city walls and follow the line of Gracechurch Street to London Bridge, for thick Roman walls have been found crossing this thoroughfare. The old London Bridge was a little to the east of the present structure, and has never been proved of Roman origin. The large number of coins, from the Republic to Honorius, and other Roman relics found in the river when the foundations of the present bridge were laid, cannot be taken as decisive, for in the vicinity of a large city the river bed is certain to contain relics at any given point, and probably as many coins and other objects will be found when the new St. Paul's Bridge is built. Further, there is no guarantee that the antiquities were dropped exactly where they were found. For instance, two halves of a Viking sword have been found in different parts of the river above London, where the scour of the tide is not so considerable.

That the Romans built a bridge to carry their high road across the river at or near the point toward which earlier British roads must have converged, is more than probable when we remember that the army under Julius Cæsar collected the timber and built a bridge over the Rhine at a point where the stream is considerably wider than the Thames at London Bridge, marched over and back again, and then dismantled the bridge, all in the space of ten days. If the Romans bridged our own Tyne, as we know they did, they would in the course of four centuries have found a bridge at London not only desirable but necessary for the traffic of the chief commercial city in Britain; and as we know that a London Bridge existed in the reign of Edgar (tenth century) we can hardly attribute it to anyone but the Romans, unless, indeed, to King Alfred.

In support of this theory mention may next be made of Stoney Lane, which runs parallel to, and a few yards east of, the Ermine Street on the south bank. This is an ancient name, and may have arisen from a paved approach to the river at this point, corresponding to Stanegate at Lambeth. There is also a Stoney Street opposite Dowgate, which has led some writers to put the crossing here, in spite of the fact that the Wallbrook was then a broad tidal river. About seven furlongs south of the river the road would cross the Watling Street, and in the angle thus formed a large Roman cemetery has been discovered in the burial-ground of a chapel (now Salvation Army barracks) in Deverell Street, New Kent Road; and burials in a similar situation have already been noticed at Smithfield. This coincidence is all the more striking, as the inhabitants of Roman Southwark seem to have buried their dead generally on the outskirts of their diminutive settlement half a mile north of the cross roads in question.

North of the river the problematic course of Ermine Street is fairly marked out by the burials in Artillery Lane and Bishopsgate Street Without, Goring Street (formerly Castle Street in Bevis Marks), Fenchurch Street, Mark Lane, and All Hallows, Barking; and Billiter Street with Mark Lane may represent the ancient line. But this line is probably not so ancient as the others. It is a curious fact that this route to the north is not mentioned in the "Antonine Itineraries," a military road book of Britain of somewhat uncertain date, but, in its original form, attributed by the latest writer on the subject to the first decade of the third century, the name being presumably derived from the Antonine Emperor Caracalla (A. D. 198-207). Travelers wishing to reach the north were in that work directed to use the Romford or the St. Alban's road for the first part of what was a roundabout journey, and we can safely conclude that the road through Ware was not then in existence. In any case the direct route passed through marshy country on its way to Lincoln, and seems to be the last link in the road system round London. On the other hand, a road, which to all appearance started from the same point on the north bank of the river, seems to have been constructed at a comparatively early date in the Roman period, though no trace of it is to be found in the "Itineraries," no doubt because it was at first merely a branch road. Evidence has already been brought forward to show that the wall round London dates from the end of the third or some time in the fourth century, and the occurrence of burials flanking this road indicates that it was laid out before the building of the Wall. East of the Wallbrook, burials are rare within the Wall, but beyond that stream they are plentiful along the line in question; and it is difficult to believe that the Roman authorities would have tolerated burials in that area after the Wall was built. Though some of the burials date from the first or second century, there are others with the unburnt body that seem to belong to the period after the change from cremation to inhumation, which, in my opinion, took place about A. D. 250. The houses near St. Paul's, in one of which fourth-century coins were found, would, on this hypothesis, not have been built till the burial-ground was disused and perhaps forgotten, presumably after London became a walled city.

A glance at the map will show that a road was wanted to communicate with the great northwest highway known as Watling Street for conveyance of goods, not to mention troops, from the principal landing place in London. This end would be served by the road suggested on the plan between the Custom House, where it would join the Ermine Street, and Newgate, where it would unite with the east-and-west road and cross the Fleet by one and the same bridge. In this way the detour by Westminster would be avoided; and even if the Ermine Street was in existence when this road was planned, a good mile would be saved by traversing one side of the triangle instead of joining the east-and-west road at Norton Folgate and traversing the other two sides.

This road is marked out as well as any by the burials, and though not a continuation of any known Roman highway, has actually been found about the middle of its course. This line would link up interments in King William Street, Cannon Street, Cheapside, St. Paul's Churchyard, Paternoster and Warwick Squares, Old Bailey and Newcastle Street, and though the first two sites might be explained as abutting on a still earlier British road, the rest are obviously con-

nected with the Customs House-Newgate road, which has other points of no less interest. Its sloping course leads gradually up the steep river bank and joins the presumably British road in front of Cannon Street Station. It is just at this point that London Stone originally stood, in the middle of the road about 35 feet southwest of the recess in St. Swithin's Church wall, where a fragment is preserved; and it may well be that the stone stood at the intersection of two roads as the firmly-set "geometric" stone seems to have done at the Marble Arch. The history of London Stone has been traced back for many hundred years, possibly to the tenth century; and it has always been regarded as of monumental interest. Its medieval history need not detain us; but it is important to notice that when its massive foundations were unearthed by Wren after the Fire, they seemed to him to have formed part of some public building; and tradition has it that this was the mile-stone from which all distances were measured in Britain.

The two roads that met in Cannon Street would probably cross the Wallbrook by a single bridge and part company again on the western side; that on the north passing along Budge Row and crossing Queen Victoria Street between two churches, St. Mary Aldermanbury and St. Antholin (now demolished). Excavations in 1869 revealed a road at a depth of 10 feet 3 inches at this spot, nearly in a line with the present Watling Street. "It was hard and well made, slightly elevated in the center and formed of rough stones and gravel, in the upper portion of which were found quantities of broken Roman pottery which, with other local circumstances, would lead us to the conclusion that it marked the course of a road or highway of some antiquity." For a short distance west of this point our line runs along Watling Street, where it has been found, and the name is more or less appropriate, as this road probably superseded to a large extent the Westminster portion of the Watling Street from Kent, when London had risen into importance. Its connection with St. Paul's Churchyard is indicated by another discovery by Wren. "Upon demolishing the ruins after the last fire and searching the foundations of this Quire, the surveyor discovered nine wells in a row; which, no doubt, had anciently belonged to a street of houses that lay aslope from the High Street (then Watling Street) to the Roman Causeway (now Cheapside); and this street which was taken away to make room for the new Quire came so near the old Presbyterium that the church could not extend further that way at first." A similar row of wells abutted on the Roman road in Cannon Street.

There is another record of flint pavement about 13 feet from the surface, below two layers of burials on the north side of the east end of St. Paul's, and below the pavement fragments of "Samian" ware, evidently of the second century. The remarks on Roman burials near St. Paul's apply still more forcibly to the few found within the walls on the east side of Wallbrook, as in Crooked Lane, on the site of East India House and at St. Helen's, Bishopsgate. On the last site a marble cist was associated with a coin of Constantine II., which might indicate a subsequent date for the building of the wall; but the point is that no burials seem to have been found in a well-defined rectangular area roughly bounded by the Wallbrook on the west and by Cannon Street on the south. Gresham House would be about the middle of the north side, and the east would be in a line with East India Avenue. It may be accidental that London Stone is at one angle of this inclosure, which has an area of about fifty or sixty acres, closely corresponding to that of a legionary camp. The prætorium or headquarters of such a camp would approximately coincide with the site of St. Peter's, Cornhill, under which massive Roman walls have been found extending westward to St. Michael's Church and eastward under Leadenhall Market. In the opinion of Roach Smith and other well-known antiquaries these were connected with an important public building, and an apsed building resembling a basilica was found under the market. Close by, at the cross-roads, probably the Carfax of London mentioned in two ordinances of Edward III, stood the Cornhill standard, a fountain of such importance as a landmark that distances on milestones throughout England, we are told, were measured from it as from the heart of the city. There is, therefore, some ground for considering this point the center of Roman London. The city developed, I suggest, from a legionary camp, no doubt occupied in force at the very outset of the Roman conquest and possibly later by legions on the way to the front, but soon given over to a civil population, which rapidly made it the leading commercial city of the provinces. It is interesting to note in this connection that St. Peter's claims to be the first Christian church in Britain, and certainly ranked higher than a parochial church in the Middle Ages, for its school was one of four maintained by order of Parliament in London. Its foundation by Lucius in the second century is, no doubt, fanciful, but there may be some justification for the claim that it was the seat of a bishop or even archbishop in the Constantine period.

There is certainly one, and perhaps more than one, main road in or near London that awaits discovery, but perhaps those already traced will have given pause to the critical historian or archæologist. To those accustomed to the haphazard road system of modern London, the straight-edge may seem a crude and inadequate instrument for restoring the main routes of the Roman period; but our conquerors had practically a clear field and were addicted to straight roads, even in districts where they found greater natural obstacles than near London; and there are coincidences that seem to confirm the system above described. Other critics may consider that too much stress has been laid on the discovery of burials more or less in line, and may point to several burials in the London area not so arranged and presumably independent of any main road. To these I would reply that interments have been occasionally found in Britain in close proximity to Roman villas, away from main roads, and the erection of tombstones along a main thoroughfare may have appealed more to the well-to-do than to the humbler members of the community, who would be content with an unostentatious burial close at hand.

It is, from the archæological point of view, regrettable that no Roman cemetery has been thoroughly excavated and recorded in Britain, and that we have to look abroad for much of our evidence of date. Years of patient work at Silchester, for instance, have placed before us a Roman provincial town with realistic effect, but the most useful piece of work there is still undone; the burials of its Roman and perhaps British inhabitants are still unexplored and even undiscovered, and the only consolation is that they are still intact. The records of such discoveries in London are provokingly inadequate, but they have at least been collected and examined, I hope to some useful purpose; and the results obtained may, perhaps, direct attention to this period of our city's history, and rescue from destruction any similar relics of the past that may hereafter come to light.

Manganese and Silicon in Foundry Practice*

Their Uses and Limitations

By A. E. Outerbridge, Jr.

IN order that the progressive foundryman may clearly comprehend the remarkable influence that manganese, silicon and a few other elements exert (even when present in extremely minute quantities sometimes) upon iron, it is necessary that he should realize at the outset that iron when pure is always the same, physically and chemically, no matter from whatever source it may be obtained, and that all of the multitudinous variations the commercial metal exhibits may be traced directly to the effects of combinations with a few other elements. In its pure or nearly pure condition iron is an exceedingly ductile metal which may be forged and hammered, or rolled, into very thin plates, ribbons, or bars. Such bars may be bent double while cold, or tied into bow knots. The tensile strength is comparatively low, being approximately 50,000 pounds per square inch, and the metal melts at a temperature between 3,000 and 3,500 deg. F.

The addition of a very small amount, or less than one-half of 1 per cent, of carbon (whose melting-point is so high it has never been determined) lowers the melting-point several hundred degrees, and converts the metal into what is known as "mild steel," changing many of its characteristics, and greatly increasing its tensile strength.

The addition of 1 per cent of carbon gives us high-grade carbon "tool steel," having tensile strength frequently of upward of 150,000 pounds per square inch, and possessing other new valuable properties.

By still further increasing the proportion of carbon the saturation-point is passed, and "cast iron" results therefrom. Then tensile strength is again reduced, and the melting-point is still further lowered, the metal takes on entirely new characteristics, and its chemical composition becomes far more complex by reason of the creeping in of other elements for which iron possesses very strong affinities. The adding of nickel, for example, is one of the comparatively recent developments of immense practical value; yet, strange to say, natural alloys of this nature have been familiar to metallurgists for a century or more, in the large meteorites that have fallen to the earth, perhaps from other worlds than ours.

MANGANESE IN FOUNDRIES.

Manganese is a metal that for many years was regarded as a deleterious material which ruined the quality of iron or steel; yet this metal proved the salvation of the Bessemer process, and more recently Hadfield discovered that the addition of manganese in larger quantity than had hitherto been deemed permissible gave us "manganese steel," one of the most wonderful products known to man, possessing the rare combination of extraordinary strength, hardness, and ductility.

About thirty years ago I commenced a long series of investigations with this element in connection with the special kind of cast iron used for making chilled cast-iron car-wheels. Formerly, such wheels were made entirely from cold-blast charcoal iron, a product peculiarly suited for the purpose. This metal was rich in carbon, and comparatively poor in all of the other elements—viz., silicon, sulphur, phosphorus, and manganese. Good car-wheel iron has, approximately, the following composition: Carbon, 3.242 per cent; phosphorous, 0.403 per cent; silicon, 0.776 per cent; manganese, 0.391 per cent; sulphur, 0.083 per cent.

Cast iron for chilled car-wheels differs from iron for machinery castings or for general purposes mainly in its comparatively low silicon content, being less than one-half of the amount of silicon ordinarily found in iron castings, and less than one-third the quantity often found in light castings, such as pulleys. Nevertheless, the silicon in these good wheels was close up to the maximum amount permissible in chilled cast-iron car-wheels having the requisite depth of chill (or white iron) in the tread to insure high mileage.

The chilled cast-iron car-wheel is an American invention, and the name of Asa Whitney will always be inseparably associated with its history as a pioneer in its development and in its successful introduction in the early days of railroading.

As long as cold-blast charcoal iron was obtainable little difficulty was experienced in maintaining the product up to the required standard, and it is a remarkable fact that years before the chemical composition of the metal was studied, or chemical analysis was used in preparing the melts, wheels were made in which the silicon (which is the most important element of all) did not vary as much as one-half of 1 per cent. from the average amount found by Dr. Dudley in the five good wheels, the explanation being that the foundry foreman was provided with a physical analysis of his metal in the form of "chill tests" made from every tap of the cupola. By this means the required depth of chill was maintained.

In course of time cold-blast charcoal iron became more and more difficult to obtain, "warm" blast was introduced for economy both in the quantity of charcoal fuel and in the time required for reducing the iron from its ore. Instantly the quality declined, and then "hot blast" iron, made with anthracite coal, supplanted charcoal iron for almost all purposes, even the making of chilled cast-iron car-wheels. This change in practice necessitated the introduction of more scientific methods in car-wheel foundries.

It was well known that manganese caused iron to chill, and as long ago as the year 1880 the custom of introducing a certain quantity of high manganese iron into the cupola in car-wheel mixtures had already attracted attention. The tests which I was called upon in that year to make convinced me that a "manganese chill" on the tread of a car-wheel was a spurious chill, very handsome to look at, but poor in wearing properties. The crystals are coarse and lamellar, they "spall out" or break away from one another when subjected to repeated taps with a hand hammer. Moreover, the white iron caused by high manganese in a chilling mixture is comparatively soft, and may be drilled without great difficulty. The result of introducing high manganese irons in the cupola proved disastrous in car-wheels when put to se-

* Read before meeting of the American Foundrymen's Association.

vere practical tests, and the rule was therefore made that a manganese chill must be avoided.

In the course of these early investigations, however, a remarkable discovery was made, almost by accident. I found that if a very minute quantity of powdered ferromanganese was placed in the bottom of a ladle and ordinary car-wheel iron poured upon it, several curious things happened. First, a very rapid circular movement, or, rather, motion in ripples from the edge towards the center of the ladle, was immediately noticeable on the surface of the molten iron. This continued until the iron set, and was even apparent in the gates and risers of castings up to the moment of congealing. Second, when a chill test piece was fractured, it was seen that the gray-iron portion was very much darker in color, and of more open grain, than that of a similar test piece poured from the same iron untreated. Third, the white iron or chilled portion of the test piece showed no appearance of a manganese chill, the only visible change being a slight reduction in the depth of the chill. Test bars were cast from this metal, and also from the untreated iron. An average gain, approaching 50 per cent, in tensile and transverse strength, was recorded.

Analyses were made by various chemists of drillings taken from the treated and the untreated iron. These all showed that the principal change caused by the treatment had taken place in the condition of the carbon nearly one-half of the combined carbon had been changed to the graphite form. The sulphur was likewise decreased. The shrinkage of the test bars of treated iron was reduced nearly 30 per cent as compared with the same iron untreated. Various proportions of ferromanganese (containing about 80 per cent manganese) were tried, with the final result that the rule was adopted that in each ladle, holding about 600 pounds of iron, needed at that time to pour one full-sized 33 inch car-wheel, one pound of powdered ferromanganese should be used. For a number of years this method was adopted only in the car-wheel works of A. Whitney and Sons, Philadelphia; but in the course of time it became generally known and used, and although my connection with work of this nature ceased in 1887, I believe the method is still very generally, if not universally, employed.

In an address given at the Franklin Institute in 1888, entitled "Pig Iron and the Relation Between its Physical Properties and its Chemical Constituents," printed in the *Journal* of the Institute in March of that year, I made my first public announcement of these investigations as follows, in their *Journal* in March, 1888:—

"Manganese is commonly supposed to exert a hardening tendency upon pig iron; but experience has taught me to regard this as another mistaken notion; it undoubtedly produces a marked effect upon the character of the white crystalline structure. You may readily recognize 'a manganese chill' by its coarse lamellar or foliated filaments, and by the tendency which it produces to form white iron or 'hard spots' in isolated places throughout the gray portion of a casting. Manganiferous pig iron has been used to produce chilled castings; but it does not make a durable wearing surface; the chilled tread of a car-wheel, for example, produced by this method presents to the eye, when broken through the section, a handsome appearance, but the white metal is comparatively soft; it may be easily bored, and, what is more serious, it crumbles readily under the impact of rapid shocks on the rail.

"A remarkable effect is produced upon the character of hard iron by adding to the molten metal, a moment before pouring it into a mold, a very small quantity of powdered ferromanganese—say one pound of ferromanganese to 600 pounds of iron—and thoroughly diffusing it through the molten mass by stirring with an iron rod. The result of several hundred carefully-conducted experiments which I have made, enables me to say that the transverse strength of the metal is increased from 30 to 40 per cent, the shrinkage is decreased from 20 to 30 per cent, and the depth of the chill is decreased about 25 per cent, while nearly one-half of the combined carbon is changed into free carbon; the percentage of manganese in the iron is not sensibly increased by this dose, the small proportion of manganese which was added being found in the form of oxide in the scoria. The philosophical explanation of this extraordinary effect is, in my opinion, to be found in the fact that the ferromanganese acts simply as a deoxidizing agent, the manganese seizing any oxygen which has combined with the iron, forming manganic-oxide, which, being lighter than the molten metal, rises to the surface, and floats off with the scoria. When a casting which has been artificially softened by this novel treatment is remelted, the effect of the ferromanganese disappears, and hard iron results as a consequence."

It will be observed from the foregoing that manganese acts in two different and opposite ways in cast iron.

When alloyed therewith in the cupola in considerable quantity, say 2 per cent or over, it has a chilling and hardening effect, producing what I have termed a spurious chill of coarse crystalline nature, in contradistinction to the normal chill in a good car-wheel which has a fine and closely-interwoven crystalline structure.

When the alloy called ferromanganese is added in a ladle of molten car-wheel iron in the small quantity given (1 pound of alloy, containing about 80 per cent manganese, in 600 pounds of iron), it acts not as an additional contribution of 0.133 per cent manganese to the metal in the ladle, but simply as a deoxidizing and desulphurizing flux, cleansing the metal from impurities, softening it, and greatly increasing the ductility and strength without injuring the chilled tread of the wheel.

The fact that ferromanganese was found to be so beneficial in car-wheel practice soon led others to exploiting the alloy for general foundry purposes; but the conditions are here entirely different, and, in most cases, this alloy is not only of no benefit, but is actually detrimental to foundry irons. I have already explained that it changes a large portion of the combined carbon in car-wheel (or chilled roll) iron into the graphitic form; but this remarkable effect cannot take place in ordinary foundry iron, which contains usually scarcely more than a trace of combined carbon. The ignorant and improper use of ferromanganese in general foundries is sure to lead to disappointments.

SILICON FOR FOUNDRY USE.

In a pure state silicon may be obtained in three allotropic forms, quite different from one another in appearance and also in some other properties. In this respect it resembles pure carbon, which is found as "graphite," "charcoal," and "diamond." In the amorphous state pure silicon is a brown combustible powder. In crystalline form it has a red luster, and in so-called "graphitic" form it resembles graphite in appearance. In recent years silicon has been produced in commercial quantity nearly pure (98 per cent) by means of the electric furnace, and is used in steel manufacture. Its melting-point, however, is so high that it will not dissolve in molten cast iron in a ladle, as I have proved by many tests.

Formerly, silicon was regarded as a most undesirable element in pig iron for foundry use; it was thought to produce "blow-holes," and to make unsound castings.

When the suitability of pig iron for castings was determined by fracture only, as was the case in my early foundry experience, "silvery pig" or "rotten pig" or "measly pig," as pig iron which was very high in silicon was variously called, was practically an unsalable commodity to foundries, for, when silicon is present in quantity ranging from 5 to 10 per cent or over, the pig metal becomes very brittle and hard, the fracture is very light gray in color, and devoid of the crystalline structure characteristic of good metal. It is indeed totally unsuitable for castings. I well remember the consternation among several foremen when I first introduced a carload of silvery pig iron containing 12 per cent of silicon to their notice, and proposed to use a certain amount of it in the cupola mixture for the purpose of softening the iron and permitting a larger proportion of hard scrap to be incorporated, followed by their astonishment at the unexpectedly beneficial result in the melt. My records show that for several years this high-silicon iron was purchased and used as a regular component in the foundry.

In course of time the views of intelligent foundrymen changed with respect to silicon, and therewith coincidently came a change in the practice of pig-iron makers as well. No longer was it considered desirable to keep the silicon as low as possible in foundry irons; gradually the average proportion began to creep up, so that it was not necessary for me to continue to purchase 12 per cent silicon pig iron in order to obtain the amount desired in our castings, for a sufficient number of brands of iron containing the full amount of silicon desired for our smallest castings could be obtained without difficulty at the ordinary market price of No. 2 plain iron. In fact, the pendulum has now swung the other way, and I find it necessary to limit the proportion of silicon in pig-iron purchases to suit various requirements.

The American Society for Testing Materials has fixed upon certain data with respect to the average proportion of silicon desirable for castings of various kinds, after consultation with foundrymen, metallurgists, and chemists, and the information has been widely disseminated in its reports.

While experimenting with ferromanganese added in ladles of car-wheel iron many years ago, I desired to know the effect upon the metal of other similar alloys, and therefore obtained the highest grades of silicon alloys then made, irrespective of cost. The richest contained nearly 20 per cent silicon. It was a disappointment to find that even when this metal was powdered and preheated to redness, the influence on the cast iron of the comparatively small amount that could be melted in a ladle of iron without making it dull was almost inappreciable. Similar tests were made with the metal aluminium, which cost at that time $8 per pound. The results were again disappointing.

Since the first publication of my experiments, it has come to my knowledge that very impure adulterated material has been sold as 50 per cent ferrosilicon alloy to foundries. In some cases the sweepings and dross obtained from manufacturers of ferrosilicon alloys have been bought in quantity at ridiculously low prices, mixed with similar refuse from ferromanganese manufacture, the whole being ground together to form a material which is of very poor quality indeed. The temptation to do this is great, the market price of 50 per cent ferrosilicon is about 50 per cent higher than that of 80 per cent ferromanganese, and the two alloys resemble each other so closely that when broken into small lumps or grains, or powdered, chemical analysis is the only means of determining the relative proportion of each. The particles of slag, cinder, and dirt may be readily seen in the worst samples by the naked eye or by the aid of a pocket magnifying-glass.

The foundryman should understand clearly from what has gone before that ferromanganese and ferrosilicon possess entirely different functions in cast iron, and should not be used indiscriminately or in conjunction. Ferromanganese is best adapted to the treatment of high chilling iron for car-wheels or chilled rolls, or other chilled castings, where the proportion of combined carbon is large.

Ferrosilicon is best adapted to treatment of foundry iron when from any cause it is hard and brittle, since it possesses the peculiar property of softening, and at the same time strengthening, such iron. It also enables the founder to vary the grade of iron in individual ladles to suit individual castings or groups of castings. It gives the founder control of his iron after it has been withdrawn from the source of melting, a matter of great importance and value, and it enables him to use cheaper grades of iron.

Finally, I wish to say that neither ferromanganese nor ferrosilicon can be regarded as universal panaceas, as some unscrupulous salesmen would have the foundry man believe, and, while each in its proper place is of great value, they must, like all other good things, be used intelligently, and, if impure, adulterated materials are employed, they will not only prove to be of no benefit, but may be absolutely harmful.

Formulæ for Strasse (according to Donault-Wieland).—

Rock crystal	300	..	300	..
Sand	..	300	..	300
Red lead	470	..	462	..
White lead	..	514	..	512
Caustic potash	163	96	168	96
Borax	22	27	18	27
Arsenous acid	1	1	0.5	1

Formula for Soft Strass.—Rock crystal 100 parts, red lead 25 parts, soda 50 parts, calcined borax 37.5 parts, saltpeter 11.5 parts.

Formula for Hard Strass.—Rock crystal 100 parts, red lead 16.7 parts, soda 33.3 parts, calcined borax 25 parts, saltpeter 5.5 parts.

Sympathetic Ink (green, with two fluids).—Write with a solution of chlorate of soda in water and go over the dry writing with a little sponge, moistened with blue vitriol solution. The writing becomes green and permanent.

TABLE OF CONTENTS

PAGE

I. AERONAUTICS.—Protecting the Aeronaut from Lightning.—1 illustration 138

II. ARCHÆOLOGY.—A View of Roman London.—By Reginald A. Smith, F.S.A.—2 illustrations 140

III. ENGINEERING.—The Marine Diesel Engine.—2 illustrations 132
Practical Aspects of Printing Telegraphy.—V.—By Donald Murray, M.A 134
The Electric Locomotives for the Lötschberg.—By Our English Correspondent.—3 illustrations 136

IV. METALLURGY.—Flaws and "Diseases" of Metals.—Their Metallographic Diagnosis.—By Our Paris Correspondent.—9 illustrations 133
Manganese and Silicon in Foundry Practice.—By A. E. Outerbridge, Jr. 143

V. MILITARY.—Logistics.—By Major William C. Bartlett, U.S.A 131

VI. MISCELLANEOUS.—The Circumference of a Circle of Given Radius.—By Mabel Sykes.—1 illustration 135
The Evolution of the Umbrella.—By F. M. Feldhaus. 10 illustrations 137
How to Determine the Day of the Week of Previous Dates.—By Ben M. Jaquish 139

VII. TECHNOLOGY.—The Potter's Clay Industry.—By Harold J. Shepstone.—5 illustrations 129